ETCHED IN TIME
Found: art made before humans evolved

NewScientist

WEEKLY December 6 - 12, 2014

EXCLUSIVE
INSIDE GOOGLE'S QUANTUM COMPUTER
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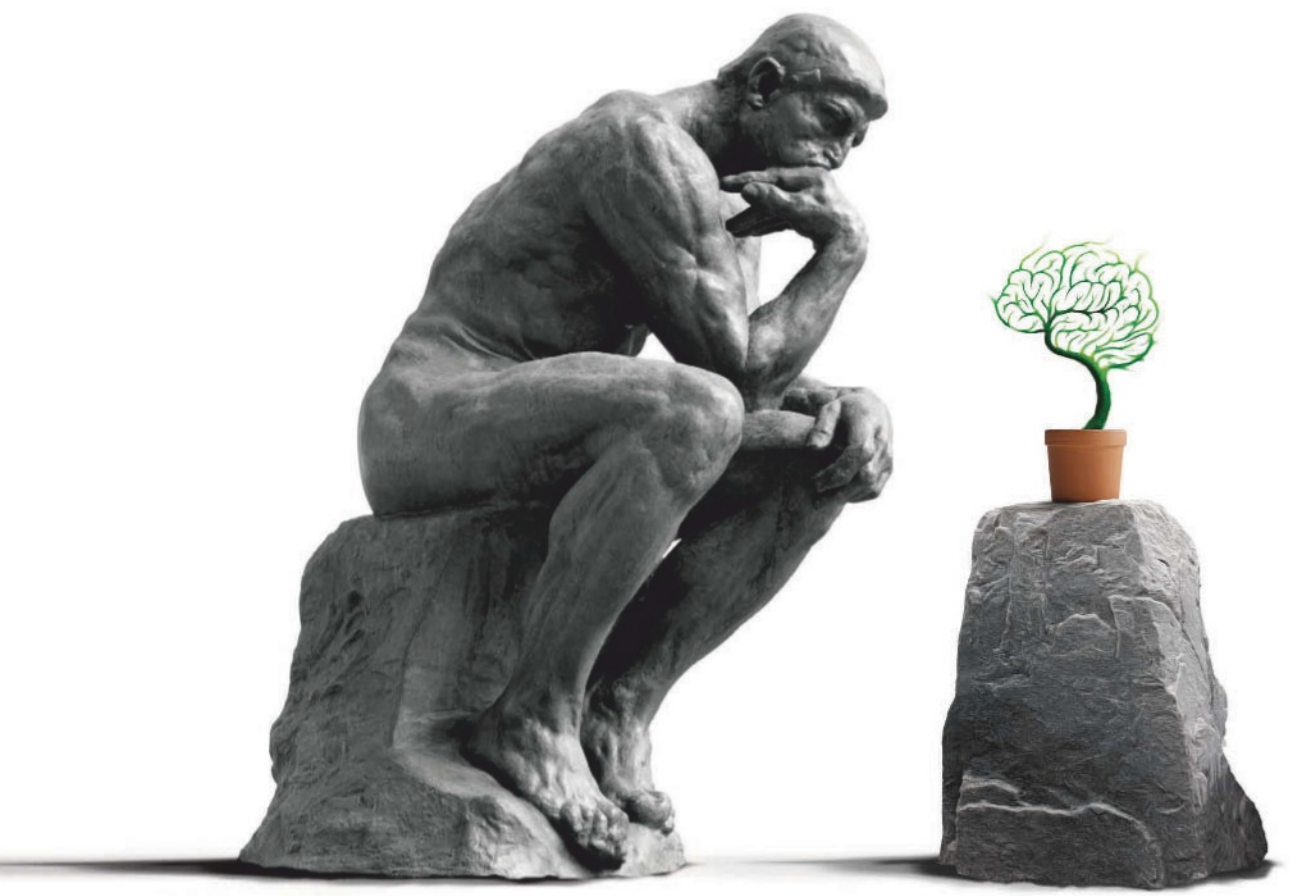
SMARTY PLANTS

They think. They react. They remember. *It's time we rethought intelligence*



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New Scientist's mission to look for life on Europa

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We evolved to make friends, not enemies

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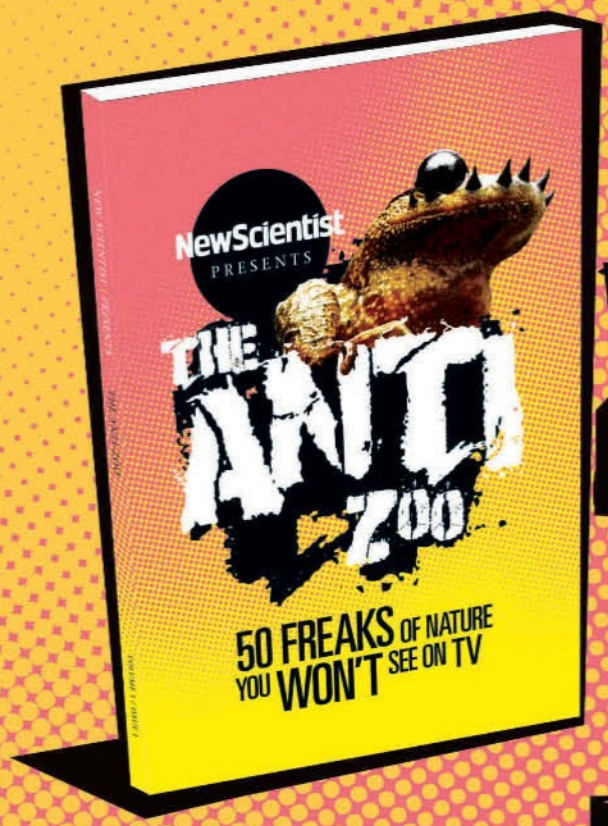

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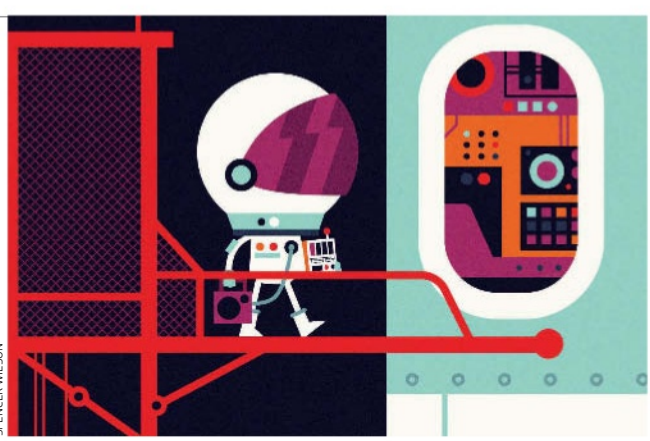

SPENCER WILSON

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Fighting fungi
The brutal world of mushrooms

The evolution of a genius ape

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UK
110 High Holborn,
London, WC1V 6EU
Tel +44 (0) 20 7611 1200
Fax +44 (0) 20 7611 1250

Australia
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Chatswood, NSW 2067
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CONTACTS
Contact us
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Who's who
newscientist.com/people

General & media enquiries
enquiries@newscientist.com

Editorial
Tel 781 734 8770
news@newscientist.com
features@newscientist.com
opinion@newscientist.com

Picture desk
Tel +44 (0) 20 7611 1268

Display advertising
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displaysales@newscientist.com

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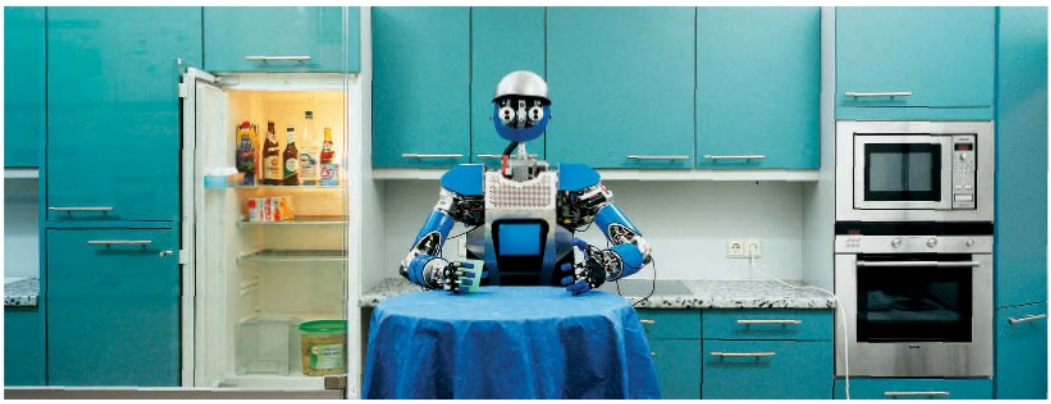


YVES GELLIE/PICTURETANK

A stranger in your place

Will telerobotics clean your house, or clean you out of a job?

THE death of distance. That was the great promise of the internet in its early days: by making cheap, immediate communication possible around the world, it would eliminate geographical constraints on relationships, media and commerce.

Twenty-odd years later, much of that promise has come to pass: all manner of work is now done remotely. Call a helpline and your query might be answered by someone halfway round the world; buy a book and it might be delivered from a warehouse on another continent. But pockets of labour have remained the preserve of humans – mostly those that involve the "last mile", where, say, parcels must be delivered or premises cleaned.

Perhaps not for much longer. Faced with the difficulty of developing genuinely smart robots, people are exploring the idea of having humans guide relatively dumb machines. Trials are under way with cleaning robots, but it is not hard to see how the same technology could be used to outsource all sorts of jobs, from receptionists to care workers.

Robotics thus has the potential to help countries that are short of labour by, in effect, importing virtual workers – if it can win public acceptance.

That will be challenging. Outsourcing has already caused economic and political upheaval; farming out yet more blue-collar work to "digital immigrants" who undercut the natives is likely to be no less disruptive.

Many of the jobs that are in the roboticists' sights are already done by immigrants. In the UK, that largely means people from poorer parts of the European Union, whose increased presence in the country is stoking anti-immigration hysteria. How digital immigrants will be received is impossible to predict.

"The technology could be used to outsource the jobs of anyone from care workers to receptionists"

Those whose jobs are on the line, meanwhile, will be hostile: a report from the University of Oxford last year suggested that as many as half of all jobs in the US could be at risk from automation and computerisation.

We are likely to see cultural difficulties arise, too. Anyone who has been shuttled from one operator to another on a helpline will understand why: the lack of a human bond engenders mistrust, and differences in etiquette can quickly foster discontent and even xenophobia. This has already begun to manifest in telerobotics tests, when early users of a cleaning service reported being "creeped out" by the idea that an anonymous stranger might be viewing them and their property through the eyes of a robot.

So researchers are now working on ways to make telerobotics more customer-friendly (see page 21). Ingenious though these are, they are open to the criticism that they are over-engineered solutions to simple problems. People trust their cleaners because they can interact with them; creating an elaborate technological solution to recreate that trust might seem overkill.

But that resistance may not last. The millennial generation, people who have grown up with video calls and instant messages, may have fewer qualms about dealing with the disembodied, particularly if introduced to telepresence in education or at work before allowing it into their homes.

For now, geography will still make a difference for those who need to press flesh and make eye contact before they can work with someone else. So reports of the death of distance have been greatly exaggerated. But that won't be the case for long. ■

JAXA

Ready to fly

Asteroid rendezvous

WE CAN'T get enough of space rocks. Just weeks after Rosetta's comet landing, Japanese space agency JAXA was this week scheduled to launch Hayabusa 2 – an ambitious follow-up to its Hayabusa probe, which landed on an asteroid in 2005.

Hayabusa 2 will peck at the asteroid's surface to take samples and place four devices on it – including Mascot, a lander based on Philae technology. More spectacularly, it will hurl a 2-kilogram explosive device called a small carry-on impactor at the asteroid to create an artificial crater. Ejected material and the rock layers can then be analysed.

Hayabusa 2 was due to launch from the Tanegashima Space Center in Japan on an H-IIA rocket and will arrive at asteroid 1993 JU3 in 2018. That rock has been chosen because its reflectivity suggests it contains much organic matter and water, hopefully revealing insights into the origins of water and therefore life in the solar system.

Unlike Rosetta, Hayabusa 2 will sample the surface itself, using a probe mechanism slung beneath the craft to catch surface dust. To aim for a good sampling spot, the spacecraft will drop a target marker – effectively a beanbag it can home in on – on the asteroid's surface. It will also sample the artificial crater it creates, and a sample return package will arrive back on Earth in 2020.

Three tiny, hopping rovers will also land on the asteroid – upgraded versions of one lost in space on the original Hayabusa mission.

Read the emotions

HOW does this make you feel? Simply asking people to think about emotion-laden actions as their brains are scanned could become one of the first evidence-based tests for psychiatric illness.

"If replicated, the technique would be a step away from diagnosis based on people's symptoms"

A team led by Marcel Just of Carnegie Mellon University in Pittsburgh, Pennsylvania, asked adults to imagine 16 actions, some of which required emotional involvement, such as "hugging" or "adoring", while they lay in an fMRI scanner.

When people with autism contemplated these emotion-linked words, a region of the brain called the posterior cingulate was much less active than in people without the condition. An algorithm can then identify who has autism on the basis of such brain activity patterns. Tests suggest it has a success rate of 97 per cent (*PLoS One*, DOI:10.1371/journal.pone.0113879).

The system may be applicable to other conditions, says Just. "We are currently running a small pilot study in another psychiatric disorder, and so far it looks promising," he says.

Assessing people in this way would be a big step away from symptom-based psychiatric diagnoses, which are often viewed as subjective and unreliable.

For now though, the results need to be repeated in a larger trial before we know if it works for autism, let alone other conditions, say other autism researchers.

Ebola slowing?

THE Ebola epidemic in West Africa might be starting to slow down. In early October, the World Health Organization vowed to slash transmission of the virus in 60 days by isolating 70 per cent of cases and safely burying 70 per cent of those who have died. That deadline passed on 1 December, and the picture is mixed but encouraging.

The burial target has been easily met and more than 70 per cent of reported cases are now isolated – but only in Liberia and Guinea, says Bruce Aylward of the WHO. In western Sierra Leone isolation facilities were built too slowly and the epidemic is still spreading fast, but as facilities become available, it is expected to slow.

"Across West Africa, we are no longer seeing exponential growth," says Aylward. There were just under 1000 new cases in the first week of October and 1100 in the last week of November – almost a plateau.

Now the task is to track down every chain of transmission, he says, and ensure that progress doesn't lead to complacency.

UNIVERSITY OF LEICESTER

Richard III?

Royal skeleton

CASE closed. A 500-year-old missing person can now be identified beyond reasonable doubt, say researchers who say the remains are those of English king Richard III.

Researchers compared mitochondrial DNA of a skeleton found under a Leicester car park in 2012 with the genes of present-day Londoner Michael Ibsen, the 17th great grand-nephew of Richard III, and Wendy Duldig, Ibsen's female-

line 14th cousin. This type of DNA is passed from mothers to their children and changes only subtly across generations. "You find an absolute perfect match between Michael Ibsen and the skeletal remain," says Turi King of the University of Leicester, who led the work (*Nature Communications*, DOI:10.1038/ncomms6631). There was also a match for Duldig, with only a single-base substitution.

The DNA evidence also suggests the skeleton had blue eyes and blond hair, which correlates with portraits of Richard III. "The evidence is overwhelming," says King.

Online abuse or not

WHAT counts as a threat online? That's the question in what may be a pivotal case in the debate over free speech and harassment online. On Monday, the US Supreme Court began hearing the case against Anthony Elonis, who was convicted after writing graphic messages on Facebook about killing and disfiguring his wife. Elonis is appealing because he claims these were not true threats but rap lyrics and that his First Amendment right to free speech has been violated.

One of his posts was: "I've got enough explosives to take care of the state police and the sheriff's department." The case is the first of its kind to reach the Supreme Court.

"Eminem rap lyrics were cited in court in an effort to get to grips with what consititues a threat online"

The ruling rests not on whether Elonis meant what he wrote, but on whether a reasonable third party could have taken the messages as a threat. Eminem rap lyrics were cited in court in an effort to get to grips with the issue.

Lift-off for Mars

A TEST flight for Mars is due to launch this week – passengers not included. NASA is set to send the Orion deep-space capsule on its inaugural uncrewed flight this week. If successful, the ship could one day ferry four astronauts on the first human mission to an asteroid or Mars.

As *New Scientist* went to press, the capsule was scheduled to launch on a Delta IV rocket early on Thursday 4 December from Cape Canaveral, Florida. Orion will circle Earth twice over the course of 4 and a half hours, reaching an altitude of 5800 kilometres at its highest point. It will then splash down in the Pacific Ocean.

NASA, and lead contractor Lockheed Martin, are looking to see how well the crew module protects its imaginary passengers. They will keep a particularly close eye on the parachutes, the heat shield – which will face a scorching 2200 °C on re-entry – and radiation levels throughout the flight. They'll also monitor how different components, such as the launch abort system, separate from the crew module.

A real mission is still some way off, though. A second test is slated for 2018, possibly followed by a crewed trip around the moon in 2021.

Tidal lagoon to boost flood defences

THE tide is turning in favour of renewable energy, at least in the UK. The Severn estuary could be the site of the world's first artificial tidal lagoon, where high tides could generate up to 320 megawatts of renewable energy a day, that's enough to power 155,000 homes.

The government is exploring the possibility of creating the lagoon in Swansea Bay in Wales. The project, proposed by firm Tidal Lagoon Power, also hopes to save more than 236,000 tonnes in carbon emissions a year, protect against coastal flooding and provide new habitats for wildlife.

The lagoon is part of the government's National Infrastructure Plan, published on Tuesday.

The lagoon would have a 6-mile, U-shaped wall, which could withstand even particularly severe, storms, the sort that happen only once in 500 years. So the wall will protect local communities and defend the coast against erosion.

In the plan, the government has also pledged £2.3 billion on 1400 other flood defence projects over the next six years. The Somerset Levels, the Humber estuary, the city of Oxford and Tonbridge in Kent are all due to have flood defences shored up as part of the plans. The government hopes the scheme will help reduce overall UK flood risks by 5 per cent.

Sean Christian of RSPB Cymru says the project's impact on wildlife will have to be carefully monitored.

JAMES DAVIES/ALAMY

Awash with energy

60 SECONDS

Personal genetics

The genetics company 23andMe is to offer a personal genome service to UK consumers despite not being able to do so in the US. The US Food and Drug Administration banned the firm from reporting health implications of people's genetics last year, citing concerns about the test's accuracy. The service is not marketed as a diagnostic tool in the UK so doesn't need regulatory approval.

Breakfast on Pluto

It's time to wake up. On 6 December NASA's New Horizons probe will wake up from its hibernation and begins the next stage of its journey to Pluto. On 14 July, New Horizons will reach its closest approach to the dwarf planet, about 10,000 kilometres above its surface, closer than some satellites orbit Earth.

Speedy speech

Stephen Hawking can now type twice as fast, thanks to a predictive computer system developed for him by Intel. Based on Swiftkey, the AI-based predictive textphone app, the system will be made open source in January to help other people with motor neuron disease.

Out of puff?

Pufferfish appear to hold their breath when they gulp water to puff up when threatened. Now, it seems they can actually still breathe because sphincters in the gut keep gills working, even although the fish stay swollen up (*Biology Letters*, DOI: 10.1098/rsbl.2014.0823).

In our time

Delegates to this week's climate summit in Lima, Peru, take note. Modelling shows that carbon emissions take only 10 years to cause warming. That means we can help our own generation, not just future ones, if we cut carbon emissions now (*Environmental Research Letters*, DOI: 10.1088/1748-9326/9/12/124002).

Etched in time

What do extraordinary shell engravings tell us about the origin of art? **Catherine Brahic** reports on the oldest etchings ever found

THE artist – if she or he can be called that – was right-handed and used a shark's tooth. They had a remarkably steady hand and a strong arm. Half a million years ago, on the banks of a calm river in central Java, they scored a deep zigzag into a clam shell.

We will never know what was going on inside its maker's head, but the tidy, purposeful line (pictured above) has opened a new window into the origins of our modern creative mind.

It was found etched into the shell of a fossilised freshwater clam, and is around half a million years old – making the line by far the oldest engraving ever found. The date also means it was made two to three hundred thousand years before our own species evolved, by a more ancient hominin, *Homo erectus*.

"It is a fascinating discovery," says Colin Renfrew, an archaeologist at the University of Cambridge. "The earliest abstract decoration in the world is really big news."

The shell was dug up in Trinil, Indonesia, in the 1890s by Dutch geologist Eugene Dubois, and was one of many fossil finds in the area, including bones of *Homo erectus* and several animals.

The shell collection sat in a museum in Leiden, the Netherlands, for over a century. Seven years ago, PhD student Stephen Munro, now at the Australian National University in Canberra, was in the country for a few days and stayed with archaeologist Josephine Joordens of the University of Leiden. She was re-exploring the Dubois collection at the time, and as Munro was also studying ancient molluscs, Joordens encouraged him to take a look. Pressed for time, he photographed each one before heading back to Australia.

"A week later I received an email," Joordens recalls. "He wrote that there was something strange on one of the shells and did I know what it was?"

Ever since then, Joordens and her team have been meticulously documenting all the Dubois clams. Sediment inside them and tiny grains pulled from cracks were dated, to reveal that they had been buried between 430,000 and 540,000 years ago (*Nature*, DOI: 10.1038/nature13962).

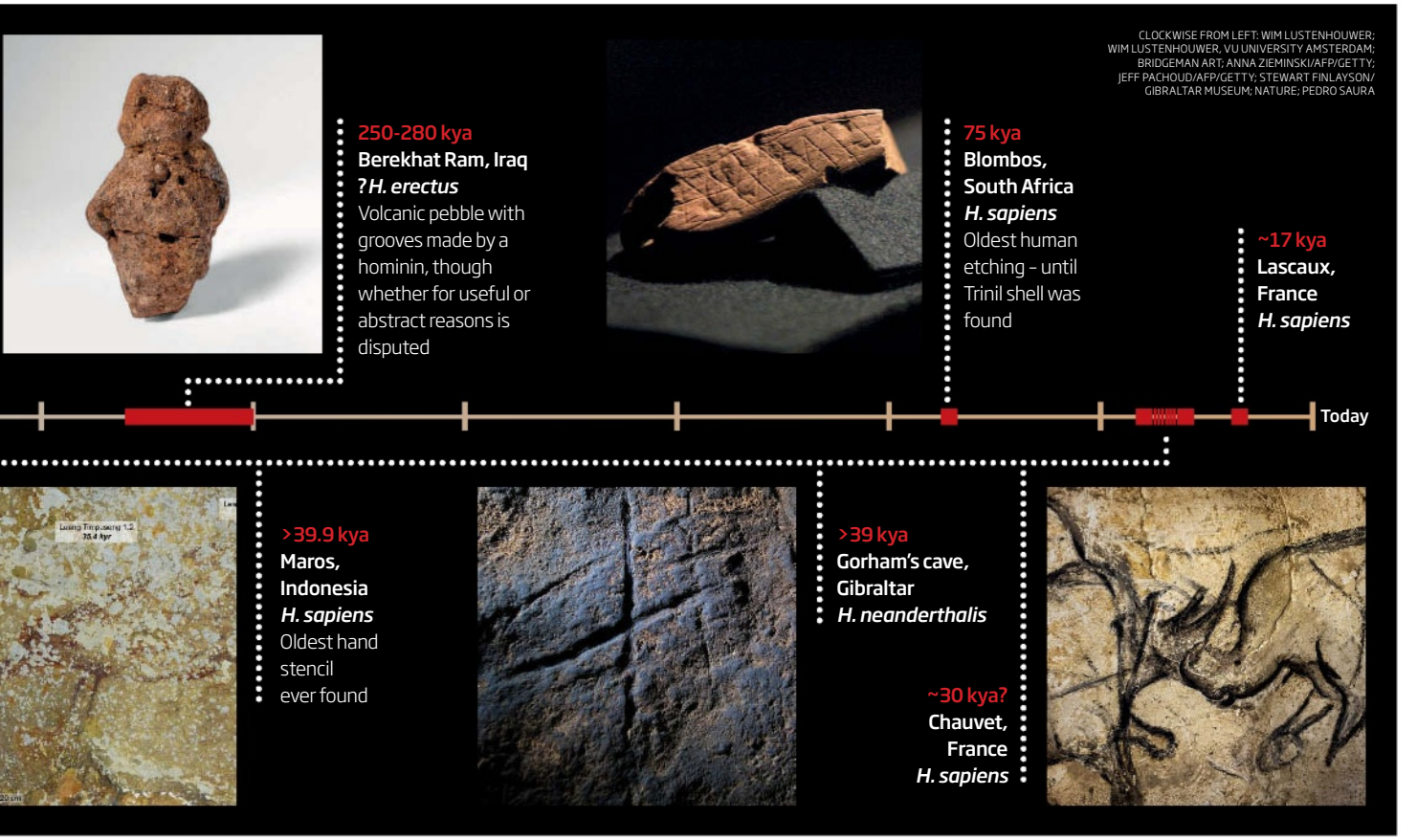
"Half a million years ago, on the banks of a calm river, someone scored a deep zigzag into a clam shell"

One turned out to be a tool, its sharpened edge probably used for scraping. Many were pierced where the clam's muscle attaches to the shell. When the team made similar holes in live clams, the damage to the muscle forced them open.

"It must have been a fairly quiet riverine environment with lots of shells," says Joordens. "Probably hominins living in the area exploited it." She says the entire site was buried suddenly, possibly the result of a volcanic eruption or a flash flood.

Meanwhile, Francesco d'Errico, a palaeoanthropologist at the University of Bordeaux in France, known for his work on early hominin engravings, tried to replicate the etch, down to its microstructure. He tested three pointed tools: a flint, a shark's tooth and a steel scalpel. The shark's tooth – many of which were also found at the Java site – offered the closest match.

The experiments showed that the line is too deep and straight to have been made by an idle hand. Fresh *Pseudodon* clam shells have a dark brown coat, so the etch would have made a striking white line. All this suggests that it was



made deliberately, and yet, unlike tools, the mark has no obvious function. It may have been a decoration, or a practice run for a decoration on another object.

That's important because *Homo sapiens* was thought to be the first species to produce abstract, non-functional designs. No other animal, not even a chimpanzee, has ever been known to make non-functional markings.

"It's very carefully done," says Andrew Whiten, a psychologist and primatologist at the University of St Andrews in the UK. "There is a wonderfully straight section and the [etch] turns in one continuous line. That's not just intentional but careful in what strikes as a very modern way. Apes aren't doing that. It would be staggering if they did."

So did the etching have some kind of meaning for its maker? And what can it tell us about the origins of complex human thought and artistic expression?

"We cannot look into the mind of the person who made it," says Joordens. But we can speculate. One thing the marks suggest is that half a million years ago, these distant ancestors already had some sense of aesthetics.

"It is emotionally touching, seeing something so old that looks like you could have made it yourself"

"So far," says Renfrew, "we haven't had much indication that *H. erectus* was doing much other than making beautiful tools and hand axes." Some see a sense of aesthetics in the tools – perhaps even making their owners more attractive to potential mates. But that is controversial and, besides, tools are undeniably useful.

Still, d'Errico suggests the lines might have been a sort of signature, indicating ownership. That would mean they had a function of sorts, but takes nothing away from their abstract nature.

"Whether the zigzag pattern had a specific meaning or was merely a sort of doodle seems irrelevant," says David Edelman, a neuroscientist who was most recently at Bennington College in Vermont. What is significant is that the shape is not immediately linked to anything concrete or to survival.

"Regardless of intent, the very process of rendering a geometric form would seem to indicate the workings of a mind no longer tethered solely to the here and now, but capable of a uniquely abstract form of conscious 'wandering'," Edelman says.

The etch also suggests *H. erectus* was integrating different domains of knowledge – thought to be a key stage in the evolution of our creative minds. "Our results indicate that these shells were seen at the same time as a source of food, a raw material to make tools, and a canvas on which to produce engravings," says d'Errico.

With only a few lines on a single shell, it is impossible to say how unusual the Trinil aesthete was at the time. It's possible – likely, according to some – that many more etchings were made on materials that did not survive or remain to be found. Or the zigzag could have been the work of a rare early creative mind.

Either way, the Trinil shell offers a compelling insight. Bones tell us about how our ancestors looked and moved. They say very little about thoughts. So in the end, perhaps the most striking aspect is the etching's familiarity. "In a way," says Joordens, "it is emotionally touching, seeing something so old that looks like something you could have made yourself." ■

Google rides D-Wave

NASA and Google are testing a quantum computer. **Jacob Aron** gets on board

THEY could be the most powerful computers in the world – so perhaps it's no surprise that the biggest internet company on the planet is testing one out.

Last year Google purchased a quantum computer from D-Wave Systems in British Columbia, Canada, currently the only firm claiming to sell chips powered by exotic physics. However, this claim is controversial; some say D-Wave has yet to fully demonstrate its chips' quantum capabilities. Now a *New Scientist* investigation reveals Google's future plans, as well as the results of its recent tests to address the quantumness controversy.

In theory, quantum computers offer a huge advantage over ordinary PCs. Regular computers code information in binary bits that are either on or off – 0 or 1. But a quantum "qubit" can be both at the same time. This could let quantum machines crunch through certain problems, like searching a database, at blistering speeds even compared to a supercomputer. Such zippy calculation is an attraction for companies like Google that deal with large volumes of data.

Google certainly isn't alone in its quantum aspirations: its D-Wave Two machine is housed at NASA's Ames Research Center in California and maintained by the Universities Space Research Association (USRA). *New Scientist's* freedom of information request to see the contract signed between the parties reveals they are pursuing a range of applications.

Aiming high

Their joint aims are easy to state, if difficult to achieve: "The goal is to develop quantum AI [artificial intelligence] algorithms, test them on real world problems and quantify the gains over classical computing machinery."

Then there are the parties' individual goals. Google wants "revolutionary new powerful quantum algorithms" for its core operations. These include ranking search results, personal assistants, ad placement and spam filtering.

Personal assistants may conjure images of a quantum-powered version of Siri, Apple's digital assistant, able to chat and joke with you. But there is no guarantee a quantum computer will be better at this than a regular computer. Google wants to be the first to find out either way.

NASA is after better algorithms for air traffic control, planning rover missions on other planets, analysing data and more. The agency has said it wants to use quantum computers to help in the search for exoplanets.

There are also plans to hook the D-Wave computer up to the NASA Ames supercomputer to develop hybrid quantum-classical AI algorithms.

At least, that's the long-term plan. However, an important stepping stone is to prove the D-Wave really can solve problems faster than ordinary PCs. Now Google researchers, working with others at NASA and D-Wave, say they've found the first evidence that it employs quantum effects to perform computation.

So far, labs around the world have been able to build machines with just a few qubits, which can only handle problems that wouldn't trouble a pocket calculator. But since 2007, when D-Wave Systems first revealed a 16-qubit chip it claimed could solve Sudoku problems by exploiting quantum mechanics, it has repeatedly ramped up the number of qubits in its computers. The D-Wave Two has around 500 qubits and the firm plans to release a 1152-qubit version next year.

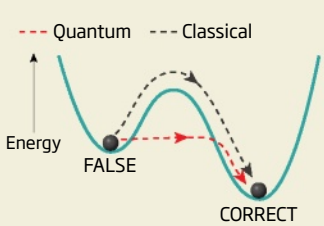
Google's got the next model up

CLINTON HUSSY

QUANTUM CHILL

To find out if Google's D-Wave is the real quantum deal, Hartmut Neven and his colleagues gave it a simple problem: an energy landscape of two valleys, one lower than the other. To find the right solution, the computer must reach the bottom of the lower valley, without getting trapped in the other, giving a false solution.

There are two ways the D-Wave could be solving this problem. A computer that employs quantum mechanics should be able to use quantum tunnelling to pass through



the hill separating the two valleys, making it more likely to succeed. This works best at low temperatures, when quantum effects are strongest. By contrast, an ordinary machine has a better chance of reaching the right answer at higher temperatures, where it has enough energy to jump over the hill.

Google's data shows the D-Wave had a 75 per cent chance of success operating at temperatures of 15 millikelvin, dropping gradually to around 65 per cent at 35 millikelvin. "The apparent trend between temperature and success probability revealed by these experiments is consistent only with quantum models," write the team.

So how is D-Wave seemingly able to out-qubit everyone else? The company uses a different approach to most others in the game, called quantum annealing. Rather than shunting qubits through the quantum analogue of the logic gates found in regular computers, it translates problems into a landscape of hills and valleys. D-Wave's qubits explore this landscape to settle on the lowest energy state, which corresponds to the solution. For this to work, the qubits must be cooled as close to absolute zero as possible – the chips are housed in a custom fridge the size of a small room.

However, critics said it wasn't clear the energy-landscape approach would provide an advantage, and had doubts that D-Wave's computers are properly quantum.

Champing at the qubit

One way to prove quantumness is showing that your qubits have a property called entanglement. This can't be measured directly while the D-Wave is operating, so it has to be inferred by other means. The firm has published a number of studies to try and demonstrate such properties, but the crucial question of whether they were actually involved in computation remained open.

Now a team led by Google's Hartmut Neven has revealed what they think is going on under the hood (arxiv.org/1411.4036). They found the computer performed better at lower temperatures – which suggests it was harnessing quantum effects during computation (see "Quantum chill").

Although hopeful, the results don't demonstrate the explosive quantum speed-up promised by theory. But the team stresses that the progress made so far is "a big step" towards proving a speed-up compared to a version of D-Wave that had no quantum properties.

"If the device had failed that test then we'd be sure that there is no chance for quantum speed-up in these types of problems," says Matthias Troyer of ETH Zurich in Switzerland, who has studied D-Wave computers in detail. "They've seen the machine uses quantum mechanics to solve a problem."

But Troyer says Google is likely to be disappointed by these results. "They wanted to write something on the tests of the past year, it's not the real great breakthrough that they had hoped for."

The variation in performance with temperature also means cooling the D-Wave computer is vitally important. But *New Scientist* obtained reports for the period July 2013 to July 2014 that reveal struggles with the water supply at the NASA Ames facility, with a potential impact on the computer's cooling. "This doesn't mean the system won't work, it just means that it has a higher risk of unplanned down time," says D-Wave's Colin Williams.

"We are working with D-Wave and USRA to address the water supply requirements and closely monitoring the situation to ensure this does not affect the system's performance," says Rupak Biswas at NASA Ames.

That might not be the only problem. Google may be finding it difficult to work with government restrictions enforced by NASA on interacting with Iranian citizens. The July 2013 report says one Google employee, who has dual citizenship with Iran and Canada, was denied an account on the D-Wave computer by NASA security. Google did not respond to requests for comment, and Biswas says NASA is adhering to US government policy.

"There is no guarantee a quantum computer will be better – Google wants to find out either way"

Google has been upping its own quantum computing operations, separate from D-Wave, by hiring John Martinis of the University of California, Santa Barbara, to build its own quantum annealer.

Whatever the firm's aims, Troyer says new hardware is the only way to achieve quantum speed-up. "I'm very confident that one can build a quantum annealer that works better than a classical annealer for some specific well-chosen problem," he says, but whether those translate into commercially important problems remains to be seen.

Williams says Google's decision to build a quantum annealer shows that D-Wave's approach is the best option. "As we continue our technical interactions with Google I am quite sure we will learn from each other's efforts," he says. "As we have seen many times before, by the time a critic comments on our technology, their assumptions regarding it are invariably already out of date." ■


NewScientist
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A NEW LAND DOWN UNDER

HIV evolves into less deadly form

Clare Wilson

HIV seems to be slowly becoming less aggressive in parts of Africa.

The change so far has been small – equivalent to people developing AIDS about 2.5 years later than they did at the start of the epidemic – but if it continues, the disease could become substantially less dangerous. A number of factors, including drug treatment, seem to be responsible.

It was once thought that pathogens always evolved to become less deadly, so that their hosts have more chance of surviving and spreading the disease. However, we now know that evolutionary pressures can also push in the opposite direction.

To track how HIV has been evolving, Philip Goulder of the University of Oxford and his colleagues compared HIV samples from 842 pregnant women in Botswana and South Africa. In Botswana, the epidemic took off in the mid-1980s, compared with the mid-90s in South Africa – so HIV in Botswana has had about a decade longer to evolve.

When tested on cells grown in a lab, the virus from Botswana reproduced more slowly than that from South Africa, which should mean it takes longer to damage people's immune systems and result in AIDS (*PNAS*, doi.org/xhc).

"To show it's adapting so rapidly is very significant," says José Borghans of the University Medical Center Utrecht in the Netherlands.

One reason could be the growing use of HIV drugs, says Goulder. People with the most virulent form of HIV get sick sooner and start drug treatment. This reduces the level of the virus in their blood and sexual fluids almost to zero, meaning that more aggressive viruses are less likely to be passed on. "It's a benefit of therapy that nobody thought of," he says. "That's another reason to provide it."

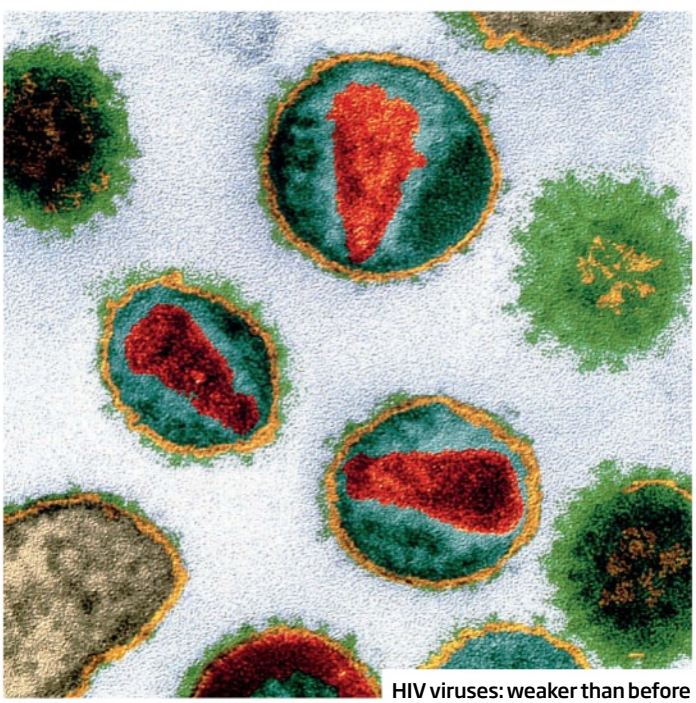
The number of people globally accessing HIV treatment has increased in recent years, rising from 5 million people in 2010 to 13.6 million this June.

But there seems to be another factor at play too – the virus is responding to people whose immune systems are naturally better at keeping the infection under control for longer.

About 15 per cent of people in southern Africa have genes that mean their immune cells are good at recognising and targeting crucial proteins belonging to the virus. In such people, HIV can only survive by mutating those proteins to evade detection, which makes it slower at reproducing. When those people pass on the virus, it retains that weakness.

"The viruses that are left are the ones that are least able to cause disease," says Goulder. His team found that in Botswana about half the viruses sampled had these mutations, compared with about 40 per cent in South Africa.

It is unclear whether similar changes are occurring in Europe and the US, although major changes are less likely where infection rates are lower. ■



EYE OF SCIENCE/SCIENCE PHOTO LIBRARY

HIV viruses: weaker than before

Once, twice, three, four times a supernova...

SEEING quadruple? For the first time, astronomers have seen an image of a single supernova split into four by a gravitational lens. The splintered stellar explosion may help calibrate distances across the universe.

Gravitational lenses are the result of massive celestial objects, like stars, galaxies or even dark matter, bending light as it passes near them. Sometimes gravitational lenses produce multiple images of a single object behind them. The effect is similar to looking at a candle through the base of a wine glass.

If astronomers can find a supernova whose light had been bent in several directions by a gravitational lens, that might tell them how quickly the universe is expanding. Each image takes a different path to telescopes near Earth, depending on how much mass is in the way. The differences in the time it takes each image to reach Earth is proportional to the universe's expansion rate. It can also give an estimate of the mass of the lensing galaxy or cluster.

Despite decades of searching, no such stellar explosions had turned up. But now, Patrick Kelly at the University of California, Berkeley, and his colleagues say they've found one.

The supernova appeared in images of the galaxy cluster MACS J1149.6+2223 taken on 10 November by the Hubble Space Telescope. Four bright sources surrounding one of the cluster's giant galaxies all appear to be related to the same object, a smaller galaxy located behind the cluster, meaning they are probably all images of the same star. The object didn't appear in earlier pictures of the same galaxy cluster, so the team think it is the bright, fatal explosion of a supernova (arxiv.org/abs/1411.6009).

"A supernova whose light has been bent in several directions can tell us the speed of the universe"

"This is a fantastic discovery," says Robert Quimby at the University of Tokyo in Japan. "The authors make a good case that this is a supernova seen through a gravitational lens."

Liz Kruesi ■

RODGER JACKMAN/OSF/GETTY

Smarter than the average mouse

Human cells stage coup d'etat in mouse brains

WHAT would Stuart Little think? Super-smart mice have been created with half-human brains.

The idea is not to mimic fiction, but to advance our understanding of human brain diseases by studying them in whole mouse brains rather than in dishes.

The mice still have mouse neurons – the "thinking" cells that make up about half of their brain cells. But almost all the glial cells, the ones that support the neurons, are human.

"It's still a mouse brain,"says Steve Goldman of the University of Rochester Medical Center in New York. "But all the non-neuronal cells are human."

Goldman's team took immature glial cells from donated human fetuses, and injected them into mouse pups. The cells developed into astrocytes – star-shaped glial cells with long tendrils. Within a year, the mouse glial cells had been usurped by the interlopers. "We could see the human cells taking over the space," says Goldman. "It seemed like the mouse cells were fleeing to the margins."

Astrocytes are vital for conscious thought because their tendrils help to coordinate the transmission of electrical impulses. Because human astrocytes are 10 to 20 times the size of mouse astrocytes and carry 100 times as many tendrils, this means they can coordinate the impulses more adeptly than

"We could see the human cells taking over the space. The mouse cells were fleeing to the margins"

mouse astrocytes can. "It's like ramping up the power of your computer," says Goldman.

Standard tests for memory and cognition showed that the mice with human cells were smarter than their normal siblings. For example, their memory seemed about four times better.

"These were whopping effects," says Goldman. "We can say they were statistically and significantly smarter than control mice" (*The Journal of Neuroscience*, doi.org/xfk).

Goldman first reported last year that mice with human glial cells are smarter. But the human cells his team injected then were mature, so they simply integrated into the brain tissue.

This time, the group injected the precursors of these cells, glial progenitor cells, which were able to divide and multiply. That, Goldman says, explains how they were able to take over the mouse brains, stopping only when they reached the limits of the space.

"That the cells work at all in a different species is amazing, and poses the question of which properties are being driven by the cell itself and which by the new environment," says Wolfgang Enard of Ludwig-Maximilians University Munich in Germany.

Although it may sound like too much tinkering with nature, Goldman is quick to dismiss any idea that the added cells somehow make the mice more human. However, the team opted not to try putting human brain cells into monkeys. "We briefly considered it but decided not to because of all the potential ethical issues," Goldman says. Enard agrees that it's a tricky question: "If you make animals more human-like, where do you stop?" **Andy Coghlan** ■

Armies of ants keep New York squeaky clean

THE hot dog is a New York staple. But we are not the only ones who like a sausage in a bun. Armies of ants do a very important job – they clean up food litter left by messy eaters of hot dogs, cookies and potato crisps.

In fact, ants and other arthropods on Manhattan's Broadway and West streets can remove food litter equivalent to the weight of about 60,000 hot dogs or 600,000 potato crisps in a year (*Global Change Biology*, DOI: 10.1111/gcb.12791) .

The US spends an estimated $11.5 billion annually on cleaning up rubbish. Large cities dispose of about 10 kilograms of litter per person per year. This means the contribution of ants to keeping the streets clean is "modest but notable", the authors say.

Elsa Youngsteadt from North Carolina State University in Raleigh and her colleagues placed three commonly dropped foods – potato crisps, cookies and hot dogs – at dozens of sites in Manhattan's parks and islands of greenery between lanes of traffic.

Arthropods removed as much as 59 per cent of the food within a day. More food was eaten at traffic islands than in parks, even though parks were more biodiverse. This may be down to the pavement ant, which lives in big colonies and likes these islands.

"Recycling is among the least glamorous of ecosystem services provided by arthropods, and this was a great study highlighting both its magnitude and importance," says May Berenbaum of the University of Illinois at Urbana-Champaign.

Such findings could be useful for urban policy and planning, says Harini Nagendra of Azim Premji University in Bangalore, India. "Most of us have seen ants laboriously lugging away fragments of a potato crisp or a cookie, but they have certainly not featured much in discussions about how to manage food waste in our cities," she says. Shreya Dasgupta ■

JOHN CANCALOSI/GETTY

I'll have mine with some spines to go, thanks

TALK about being prickly. The spines that are normally such an effective defence for cacti become a positive hazard in the presence of a white-throated woodrat.

For this small rodent (*Neotoma albigula*), commonly found in the deserts of the south-western US, spines are the equivalent of a neon sign pointing to an all-you-can-eat buffet. In fact, when offered a choice, it prefers a cactus bristling with spines to one without.

Kevin Kohl of the University of Utah in Salt Lake City and his colleagues offered woodrats a selection of cacti to feast upon, with and without spines (*Oikos*, doi.org/xd4).

"Every animal preferred the spiny cacti over the ones without spines," Kohl says. This may be because the flesh of spiny cacti generally has a higher protein content and less fibre compared with naturally non-spiny cacti – and the rats use spines as a guide to their meal's nutrition.

Having filled their bellies, the woodrats have one further irony to inflict on the hapless cacti: they use the spines for their own defences, placing them throughout their nests so that anyone paying a visit will encounter a sharp welcome.

"The spines line the entrances and runways inside the nest, making it much like a fortress," says Denise Dearing, also at the University of Utah and a senior author of the study. "The spines can defend against snakes or other predators that try to enter the woodrats' nests."

Extrasolar planets face life paradox

EARTH-LIKE planets may be stuck in a catch-22 that makes the existence of life very unlikely. They would need stable, warm climates for complex life to evolve, but without complex life their climates may never stabilise.

Earth has a carbon-silicate cycle that acts like a thermostat over geological timescales. High temperatures increase weathering of silicate rocks, and this sucks carbon dioxide out of the atmosphere and into the oceans – a process aided by plants. Lower CO_2 levels cause temperatures to fall, leading to widespread glaciation and less silicate weathering. Levels of atmospheric CO_2 later rise, leading to warmer temperatures.

"A natural question then is how efficiently does [this cycle] work on other planets," says Kristen Menou of the University of Toronto in Canada.

Menou considered Earth-like extrasolar planets that lie at the far reaches of their host star's habitable zone, which would receive low levels of sunlight. In the absence of complex plants, Menou's analysis shows that these planets would remain glaciated much of the time and only transiently enter a state with enough liquid water for life to take hold (arxiv.org/1411.5564v1).

Chemical eases heart attack harm

A DOSE of iodide, a super-safe chemical, may cut damage after a heart attack.

Heart attacks can happen because of a blocked artery, but fatal damage often happens when blood flow is restored. When flow is restricted during the attack, heart cells slow their metabolic activity. Once restored, by widening the artery during treatment, say, metabolic activity leaps up to several times higher than it was before. This produces unusual molecules that get attacked by the immune system, causing tissue damage.

To see if he could reduce this, Mark Roth at the Fred Hutchinson Cancer Research Center in Seattle triggered heart attacks in mice. He gave the rodents either iodide or saline 5 minutes before removing the blockage. Mice that received iodide had 75 per cent less dead heart tissue than those given saline (*PLoS One*, doi.org/xd5).

Brain zapping's big effect questioned

ZAPPING the brain with electricity improves memory, maths and creativity. Or so it is claimed – but a review of the technique suggests it has almost no physical effect.

Transcranial direct current stimulation (tDCS) passes a weak current through the brain, altering the likelihood of neurons passing on signals. This is tricky to measure, so it is inferred from things like changes in blood flow.

However, when Jared Horvath at the University of Melbourne in Australia pooled the results from 117 studies, he found no clear effect of tDCS on such measures. What's more, just 25 studies used a control condition, making it impossible to know whether tDCS caused any changes seen (*Neuropsychologia*, doi.org/xd9).

Yellow alert, killer plant on the prowl

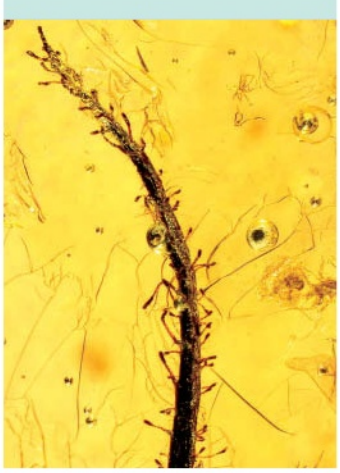
IT LURKED in wait for unsuspecting prey on the swampy Baltic coastline 35 to 47 million years ago. Now the first fossilised specimens of a carnivorous plant are helping scientists probe the organism's early evolution and their Eocene habitat.

Researchers from the University of Göttingen in Germany found the fossil of two leaves from the plant in the Jantarny amber mine near Kaliningrad, Russia (*PNAS*, DOI: 10.1073/pnas.1414777111). It appears to be related to plants from the Roridulaceae family, which catch their prey using long, sticky hairs.

"We were all so excited when we discovered it because it's very beautiful and striking," says lead researcher Eva-Maria Sadowski. "It's amazing to look at something so old, yet so well preserved."

The fossils were a long way from where this family is endemic: South Africa. "It was surprising to find the fossils in Europe. It suggests they were probably more widely distributed than initially thought and later restricted to a few places," says co-author Alexander Schmidt.

The leaves have tentacles that could have been used to capture prey – though scientists still don't know exactly what they fed on. The plant lived in forests growing on nutrient-poor soils and in swampy coastal areas, in a subtropical climate.



ALEXANDER R. SCHMIDT, UNIVERSITY OF GÖTTINGEN

Time cloak hides messages in gaps between photons

WANT to send secret messages right under someone's nose? A new "time cloak" that conceals events can keep messages secret through a trick of light, making information invisible to all but the intended recipient. Like an invisibility cloak that makes something disappear in plain sight, a time cloak makes an event disappear in time. It works by manipulating light travelling along an optical fibre.

Imagine a row of cars speeding along a road slowing in concert to create brief paths for pedestrians to cross. When the cars speed up again and rejoin the other traffic, no one can tell there was ever a gap in the flow – the pedestrians' presence has been cloaked.

In the same way, photons' paths can be tweaked to create brief gaps where information can safely hide, like a pedestrian dashing across the street.

Joseph Lukens, an electrical engineer at Purdue University in West Lafayette, Indiana, and his colleagues created two communications channels using lasers tuned to two different frequencies. One is a regular frequency and the other is a time-cloaked channel that remains hidden unless you know it's there. Photons from each laser travel along the same fibre, and the intended recipient just needs to tune in to the right channel to reveal the secret information (*Optica*, doi.org/xdz). "One guy sees nothing, the other guy sees everything," says Lukens.

Not only can the cloak deliver the messages; it also successfully fended off outside attempts to scramble the information.

Lucky strike in mineral hunt

THE most common of things can be the most difficult to find. Half a century of search for the mineral that makes up 38 per cent of Earth's volume has finally paid off – though the find came from space.

Earth's lower mantle is largely composed of a type of magnesium iron silicate that has never been found on the surface. Without a natural sample, scientists could not officially name – or fully understand – the mineral.

Now, Oliver Tschauner at the University of Nevada in Las Vegas and his colleagues have found the mineral in a meteorite and finally named it: bridgmanite (*Science*, doi.org/xhb), after Percy Bridgman, a 20th-century American physicist and Nobel laureate.

The mineral can now be chemically analysed and may help refine models of how the deep mantle behaves.

Tschauner says that because we know so little about this part of the Earth, theoretical models usually only consider the abundant elements that we know must be present, which is too crude. "You can't just ignore the rest – it doesn't work," he says.

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Graphene makes ultra-strong armour

YOU might want some layers of graphene in your bulletproof vest. Graphene – a layer of carbon one atom thick bonded in a honeycomb shape – can absorb blows that would punch through steel.

Jae-Hwang Lee at the University of Massachusetts Amherst and his colleagues devised a miniature ballistics experiment to test graphene's mettle. They superheated gold filaments with a laser pulse until they vaporised, acting like gunpowder to fire a micrometre-sized glass bullet into sheets of graphene 10 to 100 layers thick at 3000 metres per second – about three times the speed of a bullet fired from an M16 rifle.

The team found that graphene sheets dissipate this kinetic energy by stretching into a cone shape at the impact point, then cracking outward radially (*Science*, doi.org/xd7).

The cracks are one weakness of single-layer graphene, Lee says, but it nevertheless performs twice as well as Kevlar and withstands 10 times the kinetic energy that steel can. Using multiple layers of graphene or combining it with other materials could keep the cracks from spreading, too.

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Are you looking at me?

Domestic robots could be controlled by online workers, says **Mark Harris**. Will we invite strangers on the internet into our homes?

IN 2012, researchers at Silicon Valley robotics start-up Willow Garage thought they had the ideal solution for tidying their messy office. They would pay online workers to control humanoid PR2 robots remotely, cleaning up empty mugs and dirty dishes at the end of each day.

Willow Garage's experiment, however, lasted less than a month. Instead of welcoming their cybernetic cleaners, employees were creeped out. "The robots would look at you and you'd have no idea who was on the other side," recalls Maya Cakmak, then an intern at the company. "People got really uncomfortable."

Now an assistant professor of robotics at the University of Washington in Seattle, Cakmak is trying again. By obscuring personal items in the video feed seen by the cleaning robot's operator, she may have found a way to keep everyone happy.

Domestic robots are set to be a big deal. Industry analysts WinterGreen Research, based in Lexington, Massachusetts, predict that home cleaning robots will become a market worth $2.6 billion by 2020. But Willow Garage found human-controlled robots to be much more effective than the fully automatic vacuuming robots available at the time. And at just $6 an hour through Amazon's Mechanical Turk crowdsourcing service, they were also a bargain.

But what is it like for those on the other side of the camera? "Workers on a platform like Amazon Mechanical Turk have very limited rights," says Niloufar Salehi, who studies digital labour at Stanford University. "They're not subject to minimum wage, can get their account deactivated at any time or not get paid without any legal ramifications. They're on their own." For many, though, the risks will be worth it.

Willow Garage's team made plans to spin out the technology as a business – connecting domestic robots to "digital immigrant" workers around the world. The creepiness factor put those plans on hold.

Cakmak's fix, though, makes the idea viable again. This autumn, she deployed a PR2 robot in a private home in Arizona. To address the creepiness, Cakmak used digital filters in the video feed from the robot's camera to hide certain things in the robot's field of view from its operator.

To design a filter, she presented a panel of people with images of everyday objects, from the relatively innocuous, such as keys and an unmade bed, to the personal, such as credit cards and pregnancy test kits. The panel rated how comfortable they would be with digitally treated version of those images being shown to online workers.

> **"The robots would look at you and you'd have no idea who was on the other side. People got uncomfortable"**

The most privacy-preserving filter was an algorithm that pixelated parts of an image and added false colours to obscure brands and logos. Cakmak then put her filter to the test. She applied it to the video feed of a PR2 robot and tasked teleoperators to tidy up a table. The operators were then asked whether they could identify objects like political literature or medication.

Users seeing the filtered view tidied the same number of objects as those with untreated video, but were much less likely to recognise the objects they had moved. "It makes everything more abstract," says Cakmak. "Your house doesn't seem like your house anymore, it seems like any house."

The filter also works for autonomous robots with cameras. If images are later accessed, it could be just as intrusive as real-time human snoopers.

Bill Smart at Oregon State University in Corvallis is also looking at telerobotic privacy. Smart has built a system for unskilled remote operators to change bed sheets using a PR2. But rather than blurring the entire image, Smart lets homeowners specify 3D areas to censor, say a bedside table, where operators will simply see a black space. He has also developed physical privacy markers: a mat that automatically erases anything placed on it, and a hat that renders its wearer invisible in the robot's video feed.

And Savioke, a robotics company headed by Steve Cousins, formerly CEO of Willow Garage, has launched SaviOne, a robotic butler that delivers room service items to hotel guests. "Privacy is an issue," says Cousins. "SaviOne doesn't go into people's private hotel rooms. It stays in the hallway, a public space where you can't really have an expectation of a lot of privacy."

When it comes to our homes, though, we have to get privacy right, says Smart. "Otherwise it's going to be a train wreck." ■

MAX AGUILERA-HELLWEG

Robo room service

Touching the void

Handling holograms with bare hands puts the virtual world within reach, says **Chris Baraniuk**

ULTRAHAPTICS

I feel, therefore it's real

FEELING is believing. A system that uses sound waves to project "haptic holograms" into mid-air – letting you touch 3D virtual objects with your bare hands – is poised to bring virtual reality into the physical world.

Adding a sense of touch as well as sight and sound will make it easier to completely immerse yourself in VR. And the ability to feel the shape of virtual objects could let doctors use their hands to examine a lump detected by a CT scan, for example. What's more, museum visitors could handle virtual replicas of priceless exhibits while the real thing remained safely behind glass.

Ben Long and his colleagues at the University of Bristol, UK, improved on a previous version of their UltraHaptics technology, which projected 2D outlines of map contours above a screen, for example. Now, high-frequency sound waves emitted by an array of tiny speakers create the sensation of touching an invisible, floating object. When the sound hits the hand, the force of the waves exerts pressure on the skin.

To make the jump from outlines to full shapes, the team added a Leap Motion sensor to track the precise position of a user's hands. Knowing where the hands are in relation to the virtual object means the system can direct ultrasound at the right time and frequency to produce the sensation of touching different parts of the object – the top, say, or the side. This creates the impression that you are exploring the surface of an object as you move your hands around in empty space.

"Without haptics, it's like you're in a dream and you cannot feel the environment," says Sébastien Kuntz of I'm in VR, VR developers in Paris, France. "You can only look at it, you don't have any feedback."

So far, the researchers have tested several shapes, including spheres and pyramids. They appear to be gently vibrating in space, says Long. The level of detail in the virtual objects is limited, but using more, smaller, speakers should improve the resolution of what can be projected, says Long. The shapes do not need to be perfect to conjure an immersive experience, though. "Even if there are discrepancies, the brain will bend what it sees and feels to fit the overall picture," says Kuntz.

The team says it has already been approached by companies interested in developing the technology for commercial applications. The work was presented at interactive tech conference SIGGRAPH Asia in Shenzhen, China, on 3 December.

Stuart Cupit, technical director at Inition, a design studio in London, is also impressed by the technology. "Touch is a missing element in virtual interfaces today," he says. ■

Curious bots make better companions in the classroom

IT MAY have killed the cat, but curiosity could be a boon to bots. Virtual assistants, such as Siri, could be made more engaging if they exhibited a sense of inquisitiveness about the world.

Han Yu and his colleagues at Nanyang Technological University in China developed a virtual companion to guide schoolchildren through an online course. They found that children were more likely to remain focused when the companion enquired about what they were doing.

"Wah! There are so many molecules in here," says the assistant during a biology lesson. "Let's go see what they are." Instead of only directing the pupils to the answers, the digital companion was programmed to ask for their help. This encouraged the kids to be more creative and explore subjects in greater depth (arxiv.org/abs/1411.7090).

It is important not to overdo it, though. Too many questions and quizzical interjections not only make the system annoying, but can arouse anxiety and downright revulsion, says the team. To avoid such an "uncanny valley" sensation, the system monitors keyboard and mouse activity and interrupts with a "curiosity prompt" only when it detects activity dropping.

The idea could be applied to other virtual assistants, like Siri and Google Now, to stimulate a spirit of enquiry and nudge us to find information that we might not otherwise discover, says Chris Brauer at Goldsmiths, University of London, who studies such systems.

"Children were more likely to remain focused when a digital companion asked them questions"

Intellectual curiosity doesn't just help when it comes to our interactions with virtual assistants, he says. It's a key part of artificial intelligence. "These agents should be increasingly autonomous and curiosity is a significant trait for that," he says. "The more they are capable of seeking out new, interesting or unusual things, the better." Chris Baraniuk ■

Lasers to blast leaves out of trains' paths

IF THEY won't budge, zap 'em! Train-mounted lasers are being tested as a way of clearing the path for high-speed trains. What requires such forceful removal? Leaves.

Every autumn, fallen leaves are a dangerous problem for railways in much of Europe and North America. Passing trains squash leaves on the track into a hard Teflon-like residue that coats the rails, making it difficult for wheels to grip them. The reduced contact between wheels and track also affects signalling systems that are meant to keep trains from colliding. According to Network Rail in the UK, leaves caused 4.5 million hours of passenger delays in 2013.

Last month, Dutch Railways began trials to zap leaves into oblivion with lasers. Angled downwards and fitted just in front of a wheel, the lasers vaporise built-up residue as the train passes. They also dry the rails to prevent new leaves from piling up. This gives trains better traction, allowing faster acceleration and braking.

Using lasers to clear leaves was first proposed in 1999 by a UK company called LaserThor, which developed a laser with a temperature of 5000 °C that was strong enough to zap leaves 25,000 times per second. "This worked really well in the lab," says a Network Rail spokesman. But when fitted to moving trains, the vibrations made it hard to keep the laser focused on the rails, he says. Network Rail eventually opted for high-powered water jets instead.

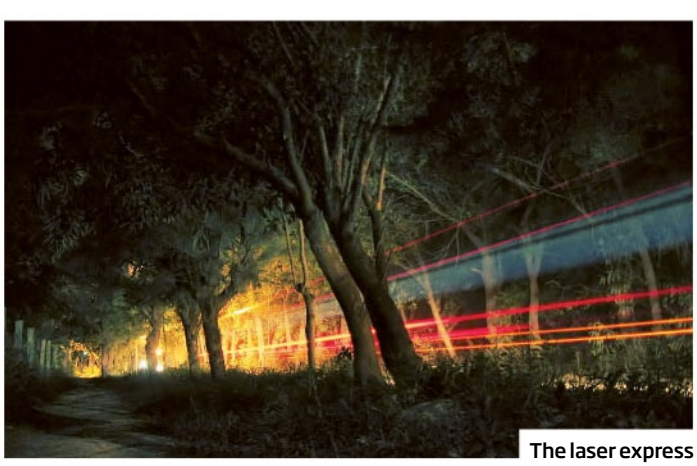
The focusing problem is one thing that the Dutch team has been working on. Their system also briefly shuts off the laser whenever vibrations make it miss the rail.

If they are to get a second chance, lasers will once again have to compete with water jets, as well as jets of a sandy-gel mixture known as Sandite, and manual scrubbing. But lasers have advantages: sand and water tanks need frequent refilling, and water jets can damage the rails and the substrate below.

> **"If they are to get a second chance, lasers will have to compete with jets of water and sand"**

According to Malcolm Higgins, the founder of LaserThor, who is also an adviser for the Dutch project, lasers will not damage the tracks. This is because their wavelength of 1064 nanometres means they are absorbed by the leaves and other organic matter such as oil, but not by metal, so energy from the lasers is reflected off the rails.

Douglas Heingartner ■



ANDRE BERNARDO/GETTY

The laser express

ONE PER CENT

Printable light

Wafer thin and dazzling white. By adding tiny LEDs to a kind of ink, lighting firm Rohinni, based in Coeur d'Alene, Idaho, has invented a light source that can be printed onto nearly any surface. The special ink forms a conductive layer that shines when powered up. Claimed to be the world's thinnest LED lighting, Lightpaper could be used to print glowing wallpaper, posters or paper-like electronic displays. The company is also thinking about printing lamp shades for lamps that would not need bulbs.

"Every PC in the company is useless and all of the content files have either been stolen or destroyed or locked away"

Following a major cyberattack on the company last week, a **Sony Pictures employee** sums up the situation to entertainment website TheWrap

Send in the robots

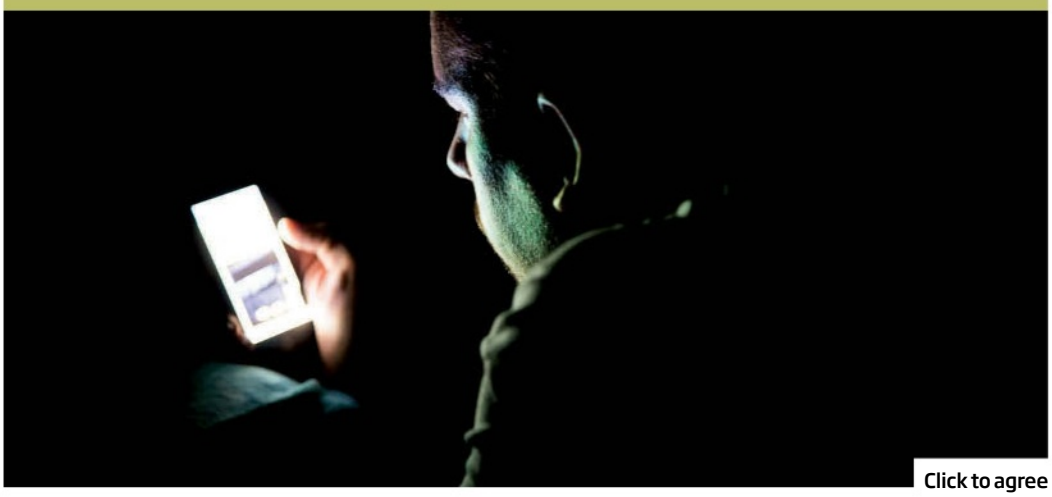
A robot is joining the fight against Ebola. Last week, healthcare technology company Vecna, in Cambridge, Massachusetts, sent a shipment that included a VGo telepresence robot to an Ebola treatment unit in Liberia. The robot will allow doctors to link up remotely with colleagues based elsewhere to discuss cases and approaches to treatment via a video feed. If all goes well, similar robots could be heading to clinics in Sierra Leone.

£17,300

The maximum fine faced by sellers of unregistered "selfie sticks" in South Korea, which are used to hold a smartphone at arm's length to take a photo. Because they trigger a phone's camera via Bluetooth, they must be officially registered as telecoms devices

GETTY IMAGES

INSIGHT Social media



ARTUR DEBAT/GETTY

Click to agree

Accept without reading?

Making social media terms of use clearer is crucial, says **Jacob Aron**

ENOUGH "meaningless drivel". That's the message from a group of UK members of parliament who have been examining how social media firms like Facebook and LinkedIn gather and use social media data.

The House of Commons Science and Technology Committee's report, published last week, has condemned firms for making people sign up to long, incomprehensible legal contracts and calls for an international standard or kitemark to identify sites that have clear terms and conditions.

"The terms and conditions statement that we all glibly tick is meaningless drivel to anyone except an American-trained lawyer," says Andrew Miller, the chair of the committee. Instead, he says, firms should provide a plain-English version of their terms. The simplified version would be checked by a third party and awarded a kitemark if it is an accurate reflection of the original.

It is not yet clear who would administer the scheme, but the UK government is looking at introducing it on a voluntary basis. "We need to think through how we make that work in practice," says Miller.

Would we pay any more attention to a kitemark? "I think if you went and did the survey, people would like to think they would," says Nigel Shadbolt at the University of Southampton, UK, who studies open data. "We do know people worry a lot about the inappropriate use of their information." But what would happen in practice is another matter, he says.

Other organisations such as banks ask customers to sign long contracts they may not read or understand, but Miller believes social media requires special attention because it is so new. "We still don't know how significant the long-term impact is going to be of unwise things that kids put on social media that come back and bite them in 20 years' time," he says.

"Unwise things that kids put on social media may come back and bite them in 20 years' time"

Shadbolt, who gave evidence to the committee, says the problem is that we don't know how companies will use our data because their business models and uses of data are still evolving. Large collections of personal information have emerged only recently as a valuable asset, he says.

The kitemark scheme is a good idea, says Hugo Roy of Terms of Service; Didn't Read, a site that crowdsources plain-English summaries of web firms' policies. But he says it would involve monitoring companies constantly, because they often modify their terms. "It's very difficult to keep up with the changes and sometimes the changes happen and nobody notices."

Easily understood terms and conditions can still obscure important details if the documents are long. For example, photo-sharing site 500px offers a plain-English version of its policies next to the legalese. But a section relating to a service letting users sell photos doesn't make it clear that users "irrevocably waive all moral rights" to their images, which isn't even enforceable in Europe, says Roy.

The outrage when a social media firm does something with data that people don't expect, even if users have ostensibly given permission, shows that the status quo isn't working. If properly administered, a kitemark on terms and conditions could help people know what exactly they are signing up to. Although they would still have to actually read them. ■

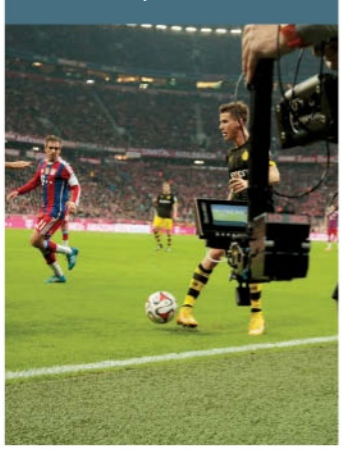
AI knows a great sporting moment when it sees one

MATCH of the Day, watch out. Computers have already tried their hand at sports commentary, now they're picking highlight clips.

Chopping out boring bits from video of sports events – leaving just the goals and penalties in a soccer match, say – is currently the work of human editors. But a system built by Arnau Raventos and his colleagues at the Polytechnic University of Catalonia in Barcelona, Spain, can do this too, creating personalised highlights for the viewer.

It starts by breaking video of a whole match into chunks, guided by cuts and fades when the camera switches between pieces of action. Those chunks are then scanned for importance. Rising noise levels and referee whistle blows tend to indicate goals, and increased movement as players jostle near the goal is a good sign of a penalty or corner kick, for example.

Replays also indicate things worth highlighting. The system searches for telltale logos that broadcasters flash at the start and end of these. Finally, it uses face recognition to determine when players are in shot, and how many there are (arxiv.org/1411.6496). Once the clips are picked, a viewer can ask the system to generate a 3-minute video just of goals and fouls, for example. Hal Hodson ■



JOHANNES SIMON/DFL/GETTY

Back from the brink

IF YOU believe the legend, Snow White and the seven dwarves lived in the Spessart, a range of wooded low mountains in central Germany – a semi-mythical region that was also home to the brothers Grimm in the 1790s.

As well as a source of folklore, it is an important region for wildlife. And it is here that the European beaver (*Castor fiber*) has been successfully reintroduced. Hunted to extinction over much of its range – it disappeared from Britain in the 16th century – the beaver is now re-establishing itself.

This one, gnawing at a tree to add to its dam, was shot by award-winning – and persistent – nature photographer Ingo Arndt. He set up a camera trap every night for 35 days to catch it. "A beaver could cut a tree like this in one night," he says. But they might start working on one tree, stop for a few nights and come back. "You really never know what they are doing." The beaver caught swimming underwater (below) was snapped in the south of France and took Arndt a mere two weeks to get.

Beavers are the largest rodents in Europe and were hunted for their fur and castoreum, a secretion of the castor glands at the base of the tail that was historically used in medicine. It is still used in perfumery and even as a food additive.

Their destructive reputation seems to belie them, but beavers are now recognised as significant resources for carbon sequestration – the wood locked up in their dams and ponds accounts for a surprising amount of carbon.

This may or may not influence a shadowy group of people known as "beaver bombers". These, apparently, are eco-vigilantes who release beavers back into Britain. Rowan Hooper

Photographer
Ingo Arndt ingoarndt.com

Two degrees of separation

The global climate target of 2 °C has been widely criticised as meaningless, but we ditch it at our peril, says **Alice Bows-Larkin**

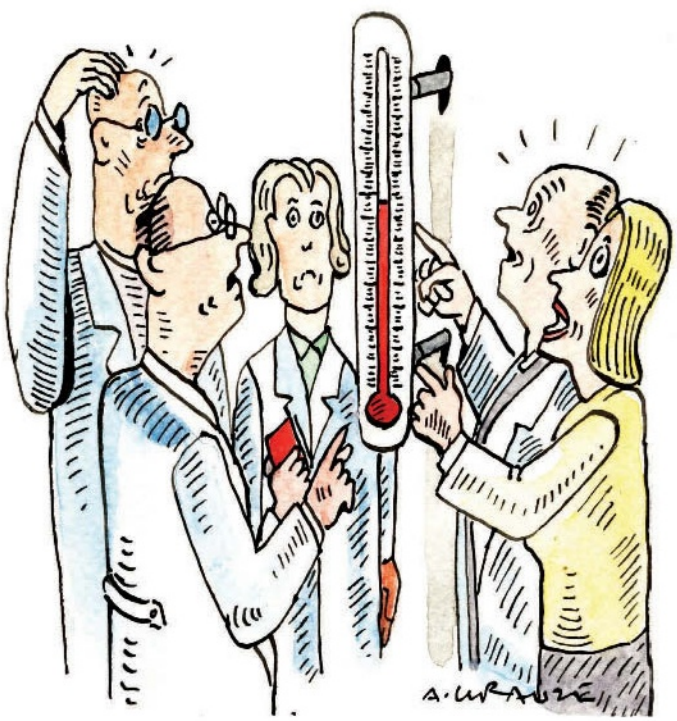
THE 20th round of climate talks in Peru's capital city Lima this month are seen as a crucial step towards reaching a global agreement in Paris in 2015.

One of the things that is likely to be discussed is whether the 2 °C target – the threshold between "acceptable" and "dangerous" climate change – should remain the world's linchpin climate policy goal. In recent months, the validity and appropriateness of this ubiquitous target have been called into question.

Concerns about the 2 °C target centre on its scientific credibility, its ability to galvanise meaningful action and its political feasibility. In October, for example, the journal *Nature* published a comment piece urging the world to "ditch the 2 °C warming goal". The authors – David Victor, a professor of international relations at the University of California, San Diego, and Charles Kennel of the Scripps Institution of Oceanography – argue that 2 °C is both scientifically and politically meaningless.

There is no doubt that the 2 °C target has its shortcomings, but the risks of jettisoning it now are too great for the planet and society to bear. Instead, scientists should learn from the criticisms to give more nuanced, transparent and honest – and therefore more effective – policy advice.

Despite its prominence in the debate, the origins of the 2 °C target aren't clear. One possible source is a 1938 study by pioneering climate scientist Guy Callendar in which he predicted that doubling the global concentration of carbon dioxide from pre-industrial levels would result in around 2 °C of warming.



Whatever its origins, 2 °C has proved to be useful when considering the subjective issue of dangerous climate impacts. The 2009 Copenhagen Accord explicitly identified 2 °C as a target, and the number has since gained considerable political importance as a way of anchoring climate politics to the science. According to many studies, 2 °C is the point around which many impacts become dangerous.

So why suggest it should be abandoned? Victor and Kennel argue that global temperature change isn't a good way to measure planetary health. There are many other physical changes that better demonstrate how our planetary limits are being pushed, they say. The heat content in the ocean, for example, is increasing more steadily than globally averaged surface temperatures. This hasn't gone unnoticed by climate deniers; they frequently point to a hiatus in temperature rises since the late 1990s and a lower than expected upward trend in the past decade.

"The 2 °C target has its shortcomings but the risks of jettisoning it are too great for the planet"

This is a valid criticism. But I argue that dropping the 2 °C target now would further confuse the already complicated choices that policymakers have to consider.

Victor and Kennel also argue that the target has been accepted without criticism and yet has proved politically influential. This is debatable. Perhaps it has been influential, but this hasn't translated into policies to put the world on track to avoid 2 °C.

Another way of looking at this is that we scientists haven't critically and clearly explained what hitting the 2 °C target would actually entail. This may be because it is politically unpalatable: some analyses predict that avoiding 2 °C threatens economic growth in wealthy nations.

One scientific framing that might work is to make a link between a certain level of cumulative greenhouse gas emissions and future temperature rises. For too long, this simple but important relationship has been underplayed. It can be used to paint realistic visions of the future and, more importantly, it shifts the focus from long-term targets to the necessity of cutting CO_2 in the next few years.

This brings me to what 2 °C means, and why I think it should remain centre stage.

The 2 °C target isn't a single target, but a probabilistic one. It tells us how much carbon we can emit (our "carbon budget") if we want a 90 per cent chance of avoiding 2 °C of warming, or a 10 per cent chance, or whatever probability we choose. In other words, there is already a huge

amount of flexibility in aiming to avoid 2 °C. That doesn't imply some sort of get-out clause, but it does mean that if 2 °C is to remain, then there are plenty of options on the table.

In short, 2 °C gives policymakers choices. Switching to some other measure, or measures, would just complicate the picture.

It isn't scientists' job to dictate how science should be used by policymakers. Instead, we should offer a thorough analysis of carbon budgets aimed at avoiding 2 °C and the implications for how quickly and deeply we need to cut CO_2, as well as the associated climate impacts that society will need to be resilient to if policies fail to deliver. We should avoid getting into the political feasibility of any required change.

If this approach had been taken a decade ago, perhaps today's policymakers would be delivering measures that cut CO_2 in line with a certain probability of avoiding dangerous warming.

Instead, we now require a new research agenda: what does it mean to radically cut CO_2 to give us a decent chance of avoiding 2 °C? Is it feasible? And how do we adapt society and infrastructure to 4 °C of warming, to account for the inevitable risk of failure?

Arguably we have been doing the opposite: advising policymakers towards policies linked to at least a 4 °C rise, while adapting infrastructure to cope with 2 °C. It is time to turn this on its head.

Now isn't the time to rethink the 2 °C goal. The climate debate is complicated enough as it is. Abandoning 2 °C, with its simplicity and value as an anchor point for debate, isn't a prerequisite for getting smarter with targets, and risks a further delay in delivering change at a point when the planet is already at breaking point. ■

Alice Bows-Larkin is a reader in energy and climate change at the University of Manchester, UK

ONE MINUTE INTERVIEW

An African numbers game

Africa must take its place on the global science stage, says **Thierry Zomahoun**, who is doing all he can to make it happen

PROFILE

Thierry Zomahoun is president and CEO of the African Institute for Mathematical Sciences. He leads the Next Einstein Initiative, which aims to create a premier scientific network across the continent

You say Africa has a PR problem. Why is maths the answer?

If we want Africa to be respected as a global player, it has to show that it doesn't need charity to handle its own problems. To be able to do that we need science, and in particular mathematical sciences, which are the backbone of every modern society. Plus, maths is free to share, it's not culturally bound, and it doesn't require heavy infrastructure. You just need paper and a pencil and you are good to go.

How was your own education?

I've been educated in Benin, Switzerland and Canada. My life started out tough, though. Nothing in my childhood predicted that I would be sitting here giving you this interview. I wasn't even supposed to go to school: I was an abandoned kid in Benin. My grandmother took me in, managed to get a small business running and was able to save money and enrol me at the local primary school. The first day she took me to school she said: "Son, I want you to know something. I'm not free because I can't read, I can't write my name. Education will set you free." Her words are still resonating in me.

How are you improving education?

We launched our first African Institute for Mathematical Sciences centre of excellence in Cape Town in 2003. We now have five centres and we aim to grow to 15 by 2025. Our faculty are volunteers from 40 countries around the globe. At each AIMS centre we offer a mix of programmes: advanced postgraduate training, research and outreach.

What happens if young people aren't given these opportunities?

Do you realise that in 2050, 40 per cent of the world's youth will be African. If the energy of this youth is not harnessed positively, it will be a disaster for Africa and also for the entire world.

How do you select students for your centres?

The number one criterion is academic excellence. We also look for a passion for Africa – we want people to give back, and come back here even if they go off to universities elsewhere. And crucially we look for leadership potential. We want to train a new generation of leaders who are capable of critical thinking; a generation of leaders who can challenge the status quo.

What's next in your ongoing campaign to promote African science?

We are organising the Next Einstein Forum – the first global forum for science to be held in Africa. It is crucial for us, firstly because there are not many young African scientists who are able to get a visa to travel to Europe or the US for big meetings. It doesn't matter how smart they are, they get turned down.

Secondly, when the media reports on Africa, the positive side is overlooked. They focus instead on Ebola or Boko Haram. So we want to put a spotlight on these young people, at least for a couple of days.

Interview by Catherine de Lange

NEXTEINSTEIN.ORG

Survival of the friendliest

Far from being savage warmongers, Pacific Islanders have a lot to tell us about the origins of human friendship, says **John Edward Terrell**

Photographed for New Scientist by Roark Johnson

PROFILE
John Edward Terrell is the curator of oceanic archaeology and ethnology at the Field Museum of Natural History in Chicago, and an expert on the biological, cultural and linguistic diversity of modern Pacific Islanders. His new book is *A Talent for Friendship: Rediscovery of a remarkable trait* (Oxford University Press)

You say that friendliness, rather than savageness, is what marks us out as a species…
People often have a grim view of what it means to be human. There's this conception that inside each of us is a Mr Hyde – an evilness that's dying to get out – and also that we can't trust strangers. This resonates with the view that at the beginning of human time we were able to survive pretty much alone or in small family groups. Supposedly we've been trying ever since then to overcome this dubious primal heritage by devising state-like organisations to control our nasty inner selves.

Yet it's pretty clear that we cannot survive on our own. Our personalities and our knowledge are so tied up in our relationships with others. As a species we are remarkably talented, not just at thinking up new ways to kill other people, but also at turning strangers into friends.

How could this innate friendliness have evolved, and how has it helped us succeed as a species?
I am not alone in thinking there's another dimension to evolution, besides mutation and natural selection, that can kick in under the right circumstances – namely cooperation and collaboration. The pay-offs for living socially are many, including avoidance of predators, finding resources and caring for young. But in order to succeed you need effective ways of communicating between the individuals involved.

Evolving the capacity to read the behaviour of others and to develop trusting relationships, as humans have, opens the door to the world beyond the confines of immediate kin and nearby neighbours.

Is friendliness unique to humans?
I think humans have probably always had, to some degree, the ability to judge the intentions of other people, to be friendly, and to take risks with strangers. As well as these evolved biological talents, we have also added cultural ways of taking the measure of others, such as how they behave when they enter a room.

However, I do not believe that we are doing something that no other species can do. For example, while we are talented at dealing with the uncertainties, risks and fears associated with meeting strangers, dogs can certainly be friendly, too, and let's not forget that bonobos are famous for forging relationships with strangers – they use sex.

Your ideas largely stem from observations of communities in New Guinea and the Solomon Islands. What were your expectations when you first landed there in the 1960s?
I was scared. When I started working in the north Solomons in 1969, things were tense. There were rumours that a major copper mine would be dug in the middle of the island, and many people there were not happy about that. And I was an archaeologist getting ready to dig in the ground looking for things. Doesn't that seem a lot like looking for copper?

So what did these communities teach you about the role of friendship in human history?
We think of New Guinea as a land of cannibals, head-hunters and constant tribal warfare. This huge island is also famous for the diversity of its languages – it is popularly said to have about 1000. The explanation invariably favoured is that people there must live isolated lives, perhaps because of the ruggedness of the mountains, or because of long-standing warfare. Yet my colleague Rob Welsch and I were astonished to learn from one man that he had "inherited friendships" with other families in 15 different communities. These were spread out over a geographical distance of 250 kilometres where 10 languages different from his own mother tongue are spoken.

Are these friendships in the way we might define them in the West?
These friendships do serve a practical purpose. If you were planning a voyage down the coast, you'd need to be sure that in your canoe was at least one person who could claim a friend in every one of the villages you'd pass. When you arrived at one of these villages, the person on board immediately connects with that friend.

A Maori *marae* is a safe place for strangers to meet and get to know each other

Even so, these relationships are not simply economic or strategic propositions: the trips are also a way of getting away from home for a spell and having some fun. We have been told on many occasions that these inherited friends are people who would be there at your funeral. The word for such friends in some local languages is the same as the word used for your spouse – I think this really signals the depth of the emotional ties often involved.

How do your ideas differ from evolutionary theories about kin or group selection?

I'm not going to say that group selection – the idea that we're social because my group has been able to outcompete your group – is never an appropriate way to account for the evolution of social cooperation in the biological world. But I don't think we need to explain the evolution of human social behaviour this way. Natural selection isn't just about individuals or groups competing with one another in the struggle for existence. Humans have to cope with a world that can rain down disease, floods, famine and other natural afflictions. Our friendships and social networks have the potential to extend the range of people we can call upon and learn from, and this can buffer us against the trials and tribulations of life.

"Our species is remarkably talented at turning strangers into friends"

What can more traditional societies teach those in the West about negotiating the balance between hostility and friendship?

I think we need to be aware of how easily we can be misunderstood by others. The Maori of New Zealand recognised this problem long ago and invented a ritual that I like to call a "*marae* encounter". This enables different communities to meet one another over a ritual battleground – rather than a real one – and take the measure of one another before getting down to business. Such encounters involve a blend of talk, performance, ceremony and hospitality. By the end, the people on both "sides" have had a chance to move emotionally from being potentially dangerous to becoming, as the Maori say, *noa* – "ordinary, safe, unrestricted". In other words, those on the other side have stopped being frightening strangers. They have become "just folks". There are lessons we can learn from this: for example, I'd love to see two Chicago gangs meet in this way on our *marae* at the Field Museum.

Have you applied anything you've learned about relationships in these societies to your own life?

One of the things I learned, both as an anthropologist and as the father of an adopted child, is that blood ties and genetic relatedness are only as meaningful as we care to make them. When I adopted my son, Gabriel, I wanted some way for him to be able to refer to his ties to us without needlessly labelling him an adopted child. I looked for words resonating with what the Samoans call a child's *aiga* – family in the broad sense of all of those supporting a child's nurturance and well-being. Then I realised we already have these great words to describe such relationships: mother, father, aunt, uncle, sister, brother. As a result, Gabriel has adopted for himself four fathers, four mothers, a much older sister, a number of aunts and uncles, and even a great grandmother.

Is modern technology ushering in a new era of human friendship?

I think it is, although it's an open question how emotionally satisfying this will be. However, I think the internet and social networking sites have tremendous potential to make the foreign not seem so foreign any more. Even a simple thing like clicking "Like" on someone's Facebook post is sending a friendly signal to someone you may never have met. ■

Interview by Linda Geddes

Screened from harm

From Toby Pereira
Clare Wilson suggests that screening for breast cancer may do more harm than good (15 November, p 14). It is not the screening that does the harm, but what is done with the information gained from it. If a group of women who are screened have worse health outcomes on average than those who aren't, the wrong action is being taken as a result of the screening.

If a new approach was taken, which was to treat unequivocal cases of advanced tumours in women who are too young to simply outlive the tumour and ignore the rest, it would surely be impossible to argue that screening was worthless.

This would not be optimal: we need to find the best compromise. To stop screening because it leads to unnecessary treatment in some cases would be no better than banning antibiotics because some doctors overprescribe them.
Rayne, Essex, UK

The editor writes
■ No one proposes that we stop screening entirely. Unfortunately we lack reliable methods of discriminating aggressive tumours from others – and, if such methods existed, women diagnosed with non-aggressive tumours would need to have quite remarkable confidence in them.

Support staff

From John Davnall
In reply to Adrian Ellis's letter, you comment that the development of an industrial civilisation might be predicated on a "critical mass of people" (15 November, p 30).This reminded me of a *New Scientist* interview with David Suzuki in which he was asked how many people our planet could support (15 October 2008, p 44).

He relayed the estimate by an unnamed Harvard scholar of "200 million if you want to live like North Americans". I wondered then whether 200 million would be enough people to produce for themselves all the features of life they would wish to retain.

Our species may be a long way from worrying about having too few members, but has anybody addressed population questions from this point of view?
Manchester, UK

Burn the midnight oil

From Phil Maguire
Tim Ratcliffe's vision of stopping investment in fossil fuels and artificially imposing a transition to a low-carbon economy would have downsides (15 November, p 26). It might slow the growth of knowledge, delay discoveries and lead to greater overall damage to the climate. Fossil fuels can be both the cause of and solution to our climate change problems.

Every barrel of oil we burn buys us new knowledge. This will eventually allow renewable energy technologies to naturally displace heritage technologies. Until that time perhaps we should respect the wisdom of markets and put economic growth first.
Leixlip, County Kildare, Ireland

From Steve O'Connor
Paul Younger seems to base his opposition to divesting from fossil fuels on a fundamental misunderstanding. He repeats the error that the divestment movement is "premised on the idea that fossil fuels can be abandoned immediately".

This is simply not the case. The spearhead of the divestment campaign, 350.org, calls for a wind-down period of five years, and an immediate freeze on new investments in what it calls the 200 worst offending companies.

A quick look at the proposed Intergovernmental Panel on Climate Change carbon budget to keep global warming below 2 °C,

alongside the fossil fuel reserves held by the industry, is enough to see that the two aren't compatible.
Canberra, Australia

Heartless killers

From Donald Hobson
Brilliant, another way to kill each other, with autonomous robots (15 November, p 38). But they can't be too effective as that would be wrong. What makes a robot that is good at killing people illegal and amoral, but a robot that is less effective but still manages sometimes fine?

Why don't countries hold some sort of contest to settle their differences instead? This could be sporting, or even something like finding the most effective cure to a disease.
Kirkton of Kingoldrum, Angus, UK

Tractor production

From Michael Bell
David Sanderson points out that farm machinery uses a lot of oil (22 November, p 34). I read of a solution to this in *Meccano Magazine* – standard reading for the technically aware schoolboy of the 1950s.

It was to provide electric power by overhead cable to the corners of fields. The electricity would be fed to vehicles by armoured cables that would be laid out on the outward ploughing run and wound in on the return.

I think it was the Central Electricity Generating Board that demonstrated prototypes, aiming to replace imported oil with home-dug coal firing power stations. It was not followed up, for the usual reason of the time: "lack of export potential".
Newcastle upon Tyne, UK

Collapse in doubt

From Martin Greenwood
Petros Sekeris may have chosen an unfortunate example to illustrate his hypothesis about violent responses to resource depletion (22 November, p 30). Jared Diamond's analysis of events on Easter Island is open to question.

There is a case to be made that, despite depletion of many resources, Easter Islanders had managed to create and maintain a stable society. That society then collapsed as a consequence of visits from the outside world.

Not only did the islanders discover they were not alone in the world; they suffered from introduced diseases. The final indignity was the forceful expropriation of their land and the introduction of sheep. Scots might sympathise.

Watch Earth society collapse when an alien civilisation arrives, with previously unknown diseases and hordes of creatures to consume our limited resources.
Stirling, Western Australia

Spot the difference

From Paul Baron
I suspect that the key question about a multiverse (27 September, p 32) is not whether multiple universes exist, but whether the difference between them is as small as the spin state of a single electron – or so great that mathematics itself is useful only in ours, and does not apply in others. (Or, of course, something in between.)
Auckland, New Zealand

Password to life

From Thomas Smith
Paul Marks refers to a TV drama in which a fictional character is killed by hacking into their pacemaker (8 November, p 19). He then explains how security experts are engaged in making it harder to reprogram medical devices, just in case anyone should want to do this for real.

In the real world, murder is infrequent, incompetence is everywhere and risk-averse computer security policies are a recurrent irritation. One might wonder whether hypothetical hackers are the right problem to be concerned about.

Nowhere in the article is there any mention of how many people

have already died because no one could find the login credentials for their medical devices in an emergency. Do we really want to make this more difficult?
Saint Louis, France

Moral code

From Jonathan Arch
Your leader on the moral implications of homosexuality being partly or largely biologically determined did not address one counterargument (22 November, p 5). There are other desires or traits that are, in all probability, largely biologically determined but which no modern society can tolerate. Why should societies forbid the practice of some desires but not others?

The answer is surely that some practices cause harm but others do not. Most readers of *New Scientist*, I suggest, do not regard the practice of homosexuality as harmful. Others may feel that its practice degrades society or even consigns perpetrators to hell, but it may be a sense of disgust that motivates such arguments. As you conclude: "Get over it."

During my lifetime, the society in which I live has come to reject arguments based on religion and accept the great harm caused by forbidding homosexuality.
Welwyn Garden City, Hertfordshire, UK

From Peter Silverman
Andy Coghlan reports a study of gay brothers that provides further strong support for the genetic basis of homosexuality. (22 November, p 11). There are, however, two counterarguments to be addressed before it can be accepted.

The first is that any gene that reduces the chance of the person carrying it reproducing should, over time, disappear from the gene pool. The second is that identical twins do not always share the same sexual orientation.

Both arguments can be addressed if the expression of the genes involved is triggered randomly during development of the embryo, not at conception. Say these genes give a 1 in 5 chance of being homosexual. They would still need to compete with variants. The "gay gene" would conceivably, therefore, have to provide a reproductive advantage. This might be connected with close relatives' reproductive success.
Ruislip, Middlesex, UK

The editor writes:
■ Something else that we didn't have space to mention is that "gay gene" carriers in both sexes have another trait in common: they are strongly attractive to men (23 August 2008, p 7).

Walking and running

From Christine Duffill
I find it hard to believe your assertion that running and walking at 6 kilometres an hour both burn the same number of calories, while dispelling myths about fat (15 November, p 32). My intuition forces me to think that there must be a difference in energy expenditure of two such different modes of locomotion. When running, the body is being propelled into the air against the force of gravity; when walking, one foot remains firmly on the ground at all times.
Southampton, Hampshire, UK

The editor writes:
■ The answer does seem to be different at different speeds. We will return to this.

Love is blind

From Jerry Shiner
Helen Thomson writes of a man who has a delusional belief his wife is an impostor, because the emotional processing in his brain does not match his visual processing (8 November, p 12).

This dramatic and moving example illustrates the irresistible triumph of emotion over the insurmountable evidence of the senses.

It is frightening and gloomy to see how difficult this makes it for the species to do the right thing.

On the other hand, it is the same mechanism that allows me to avoid despair and believe that my grandchildren will muddle through climate change, corporate greed, governments and our other legacies.
Toronto, Ontario, Canada

Dangerous tritium

From Paul Collins
The article discussing the possibility of generating energy using small-scale nuclear fusion suggested that both deuterium and tritium are stable isotopes of hydrogen. Although deuterium is a stable isotope, tritium certainly is not (8 November, p 9).

It is a low-energy beta emitter with a half-life of 12.3 years. It decays to helium. Further, tritium is very dangerous because it can incorporate easily into skin and into bodily fluids.
Eastbridge, Suffolk, UK

For the record

■ **We got the name of one of the two founders of the Bill and Melinda Gates Foundation wrong (25 October, p 40). Sorry.**

■ **We should have credited the launch of the OpenWorm project on Kickstarter to the community of researchers at openworm.org including Stephen Larson (29 November, p 21). Independent researcher Tim Busbice used OpenWorm data to create his robot.**

■ **Our report about internet companies being blamed for hampering the security services (29 November, p 6) should have got the name of the executive director of the Open Rights Group correct. We believe his MI5 file is in the name of Jim Killock.**

Letters should be sent to:
Letters to the Editor, New Scientist, 110 High Holborn, London WC1V 6EU
Fax: +44 (0) 20 7611 1280
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Roots of consciousness

The discovery that plants have their own kind of intelligence is both fascinating and challenging, finds **Anil Anathaswamy**

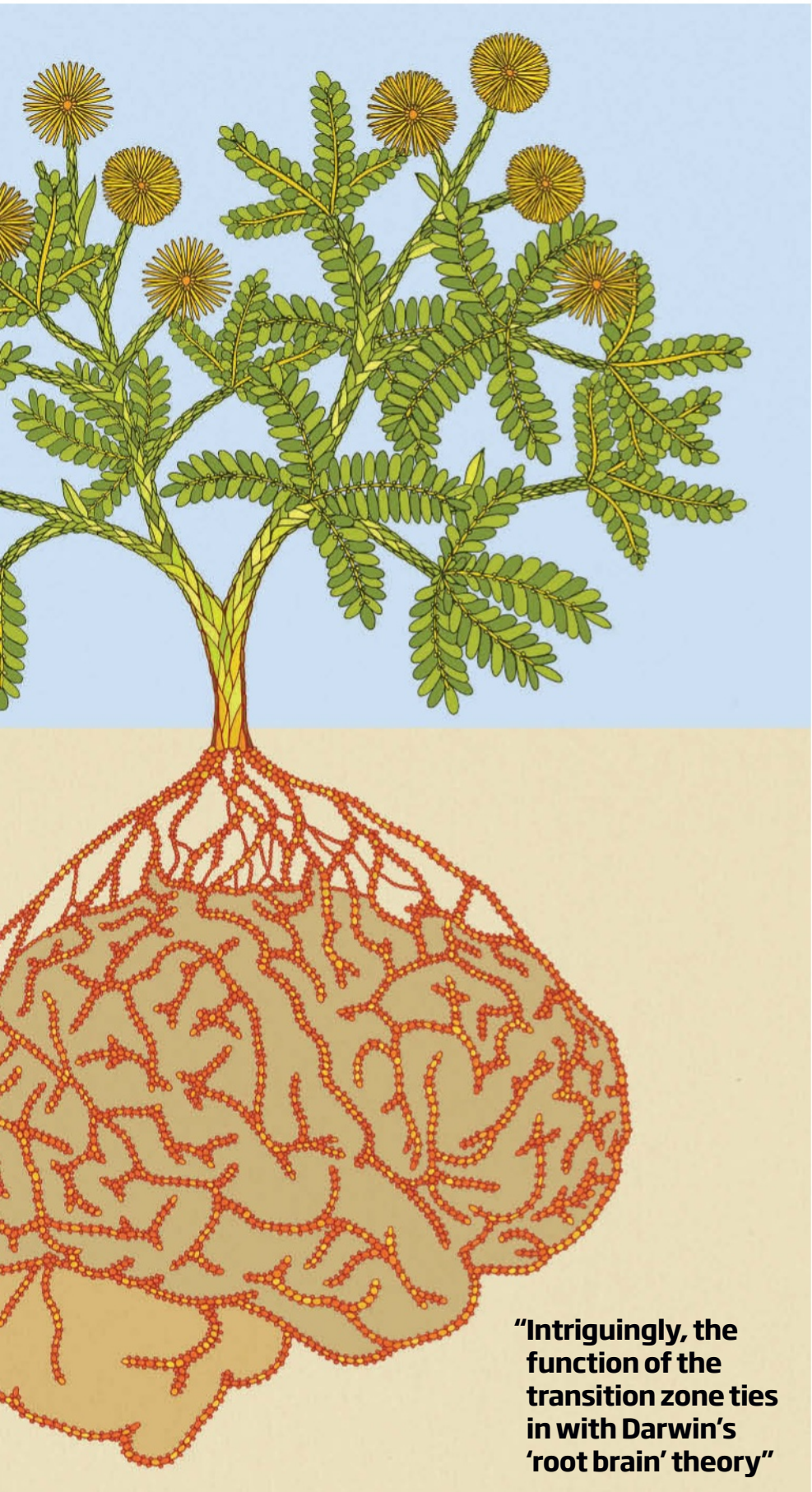
CLAIRE SCULLY

STEVE SILLETT has been hanging out with giants all his working life. He climbs and studies the canopies of giant redwoods along the coast of northern California. Sometimes, when traversing from the top of one tree to another, he is awestruck by the life that surrounds him. "There's this awareness of where you are, 90 metres up, in this breathing, living forest of ancient beings," says Sillett, who is at Humboldt State University, California. "You get into this space where you are interacting with another organism that functions completely differently."

Had Aristotle hung out among redwoods, he might not have consigned plants to the bottom rungs of his "ladder of life". But he didn't, and botanists have been tormented by his legacy. For centuries, few dared challenge his judgement. Now that's finally changing. In the past decade, researchers have been making the case for taking plants more seriously. They are finding that plants have a sophisticated awareness of their environment and of each other, and can communicate what they sense. There is also evidence that plants have memory, can integrate massive amounts of information and maybe pay attention. Some botanists ague that they are intelligent beings, with a "neurobiology" all of their own. There's even tentative talk of plant consciousness.

Charles Darwin would have approved. He was the first to seriously question Aristotelian ideas that plants don't have the stuff of life that animates us and other animals, simply because they don't move. One of his books, published in 1880, was provocatively titled *The Power of Movement in Plants*. But despite this patronage, plants didn't catch the fancy of biologists pondering intelligent life for more than a century.

Then, in 1900, Indian biophysicist Jagdish Chandra Bose began a series of experiments that laid the groundwork for what some today call "plant neurobiology". He argued that plants actively explore their environments, and are capable of learning and modifying their behaviour to suit their purposes. Key to



"Intriguingly, the function of the transition zone ties in with Darwin's 'root brain' theory"

all this, he said, was a plant nervous system. Located primarily in the phloem, the vascular tissue used to transport nutrients, Bose believed this allowed information to travel around the organism via electrical signals.

Bose was also well ahead of his time. It wasn't until 1992 that his idea of widespread electrical signalling in plants received strong support when researchers discovered that wounding a tomato plant results in a plant-wide production of certain proteins – and the speed of the response could only be due to electrical signals and not chemical signals travelling via the phloem as had been assumed. The door to the study of plant behaviour was opened.

Slow but not stupid

Even then, it would be another decade before Anthony Trewavas at the University of Edinburgh, UK, became the first person to seriously broach the topic of plant intelligence. Trewavas defines intelligence as the ability to sense one's environment, to process and integrate such sensory perceptions, and decide on how to behave. "The great problem of plant behaviour has always been that you can't see it going on," he says. There are a few exceptions, such as the snap of the Venus flytrap. "But the most visible plant behaviour is simply growth, and growth is a very slow business," he says. This problem has been reduced with the advent of time-lapse video and photography.

Take the parasitic vine Cuscuta, also known as dodder. In time-lapse, a dodder seedling seems to sniff the air looking for a host, and when it finds one, it lunges and wraps itself around its victim. It even shows a preference, choosing tomato over wheat, for example. "It is remarkably snakelike in the way it behaves," says Trewavas. "You'll stop doubting that plants aren't intelligent organisms, because they are behaving in ways that you expect animals to behave."

Once Trewavas mooted the idea of plant intelligence, others soon backed him up. So much so that in 2005, the Society for Plant Neurobiology was formed to foster debate and change the way we think about plants. "There is a kind of brain chauvinism," says Stefano Mancuso, one of the founders based at the University of Florence, Italy. "We think that a brain is something that is absolutely needed to have intelligence." Not so. Despite a lack of neurons and an animal-like nervous system, plants are perfectly capable of processing and integrating information to generate ›

The touch-me-not learns to stop reacting to a sham threat in just four lessons

behaviour that can be called intelligent. Mancuso and society co-founder Frantisek Baluska at the University of Bonn, Germany, believe that roots are the key.

A root is a complex assemblage. There's the root cap, which protects the root as it navigates through soil, but also senses a wide range of physical properties, such as gravity, humidity, light, oxygen and nutrients. Behind this is the meristem, a region of rapidly dividing cells. Further back is the elongation zone, where cells grow in length, allowing the root to lengthen and bend. And between the meristem and the elongation zone is a curious region called the transition zone (see diagram, right). Traditionally, it was thought to have no purpose, but Baluska and Mancuso think it is actually the nerve centre of the plant.

Underground intelligence

They have found that the transition zone is electrically active. What's more, within it a hormone called auxin, which regulates plant growth, is ferried around in protein containers called vesicles that are reused once they have released their load. This is similar to the transport of neurotransmitters in animal brains, where vesicle recycling is thought to be important for the efficient and precise information exchange across synapses. The transition zone is also a major consumer of oxygen, in another curious analogy to the human brain. All of which leads Baluska and Mancuso to suggest that this is where sensory information gathered by the root cap is translated into commands for the elongation zone – and so control of root behaviour.

Intriguingly, this ties in with Darwin's "root brain" hypothesis. In the last paragraph of *The Power of Movement in Plants*, he dared readers to think of the root as the intelligent end of a plant. Referring to a plant's primary root, or radicle, he wrote: "It is hardly an exaggeration to say that the tip of the radicle… acts like the brain of one of the lower animals."

"He was right once more," says Mancuso. "If we need to find an integrative processing part of the plant, we need to look at the roots."

Parallels with animal intelligence don't end there. Besides the tantalising brain-like behaviour of the root's transition zone, many plant cells are capable of neuron-like activity. "In plants, almost every cell is able to produce and propagate electric signals. In roots, every single living cell is able to," says Mancuso. Likewise, the phloem is extremely electrically active, and capable of fast electrical signalling. "It is some kind of huge axon, running from the shoot tip to the root tip," says Baluska.

There's also the curious fact that plants produce chemicals that in animal brains act as hormones and neurotransmitters, such as serotonin, GABA and melatonin. Nobody quite knows the significance of these chemicals in plants – it could simply be that evolution has come up with similar molecules for very different purposes in plants and animals. Nevertheless, Susan Murch of the University of British Columbia in Kelowna, Canada, has shown that drugs like Prozac, Ritalin and methamphetamines, which disrupt neurotransmitters in our brains, can do the same in plants. "If you really mess with a plant's ability to either transport or make melatonin or serotonin, root development is very strange – they are malformed and disjointed," she says.

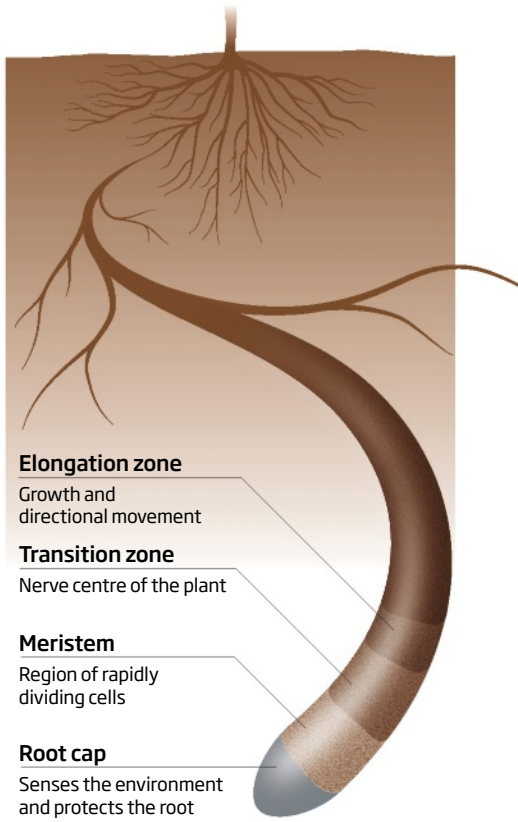
Despite all this, the term "plant neurobiology" is controversial even among some of the most vocal advocates of plants. Daniel Chamovitz at Tel Aviv University in Israel says it's an oxymoron. "Plants just don't have neurons. It's like saying 'human floral biology'," he says. Indeed, the Society for Plant Neurobiology met with so much resistance that its founders were forced to change its name to the less controversial Society of Plant Signaling and Behavior.

Nevertheless, Chamovitz and others don't dispute that plants are extremely aware of their environment, and are able to process and integrate information in sophisticated ways. In fact, a plant's awareness of its environment is often keener than an animal's precisely because plants cannot flee from danger and so must sense and adapt to it. For instance, while animals have a handful of photoreceptors to sense light, plants have about 15. "Plants are acutely aware of their environment," says Chamovitz. "They are aware of the direction of the light and quality of the light. They communicate with each other with chemicals, whether we want to call this taste, or smell, or pheromones. Plants 'know' when they are being touched, or when they are being shook by the wind. They integrate all of this information precisely. And they do all of this integration in the absence of a neural system."

Plants also manage to remember things without the benefit of neurons. Memory can

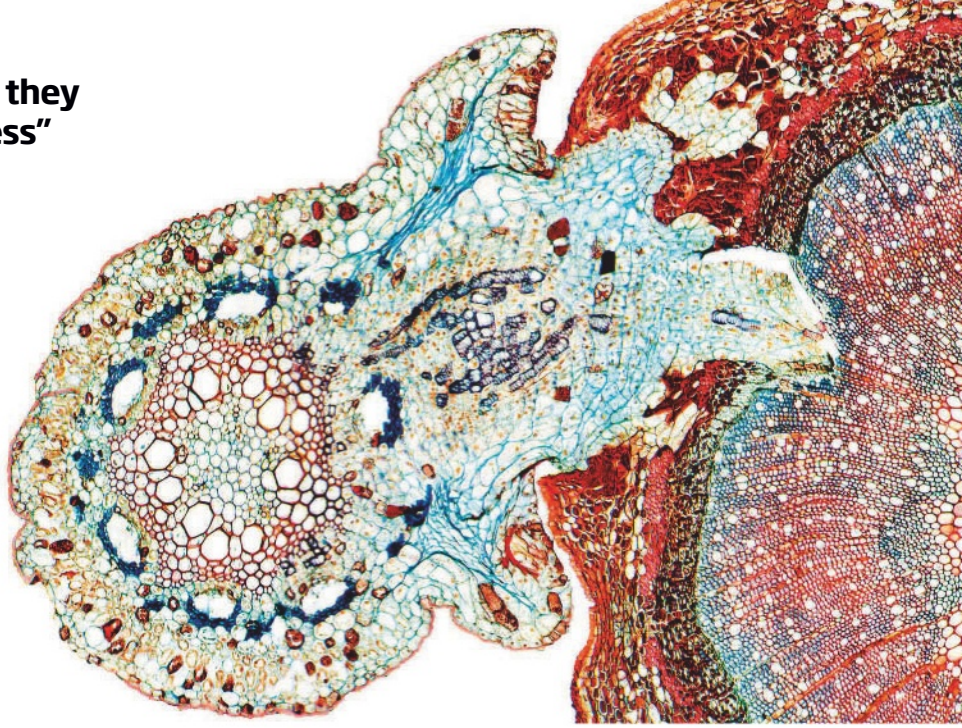
Lateral thinking

Once considered to have no purpose, the transition zone near the tip of each root may be a kind of brain



FRANK GREENAWAY/DORLING KINDERSLEY/GETTY

"Plants may even feel pain, a sign they could have a kind of consciousness"



Time-lapse video reveals parasitic vine dodder to be remarkably snakelike in pursuit of its prey

be defined, according to Chamovitz, as "recording an event, storing that event and recalling it at a later time in order to do something". And plants certainly do this. For example, just one touch isn't enough to spring the jaws of a Venus flytrap. Instead, it remembers the first touch and if it senses another within 30 seconds it snaps shut. That's because the first touch causes molecules to build up in the trap's sensory hairs and the second touch pushes the concentration of these across a threshold, resulting in an electrical impulse that activates the trap.

Smarty plants

There is even evidence that plants have long-term memories. *Mimosa pudica*, the touch-me-not plant, can close its leaflets when touched, but this defensive behaviour requires energy, therefore the plant doesn't indulge in it unnecessarily. When Mancuso and colleagues dropped potted mimosas on to foam from a height of 15 centimetres, the plants closed their leaves in response to the fall. But after just four to six drops they stopped doing this – as if they realised that the fall posed no danger. However, they continued to close their leaves in response to a physical touch, which would normally presage being damaged or eaten. "Even after one month, they were able to discriminate and be able to understand whether the stimulus was dangerous or not," says Mancuso.

This is all very clever, but it's not intelligence, says Chamovitz: "I don't like the term plant intelligence. We don't even know what intelligence is for humans. If you get five psychologists together you will get 20 different definitions."

Murch agrees. She acknowledges that plants seem to possess the various elements that make intelligence possible – sensing, awareness, integration of information, long-term memory and adaptive learning – but she is not convinced this adds up to intelligence. And despite years spent among towering redwoods, Sillett is also doubtful. "I wouldn't call it intelligence, but awareness. These trees are keenly aware of their environment, and they respond to it in many ways that we can measure as performance."

But while many researchers are cautious, others are keen to push the way that we think about plants into even more disputed territory. Baluska suggests that plants may even feel pain, and argues that this is a sign that they have a kind of consciousness. An animal can be knocked out with anaesthetics, including the gas ethylene. Plants produce ethylene to regulate everything from seed germination to fruit ripening. They also release it when stressed – when under attack by predators or being cut by humans, for example – and nearby plants can sense it. "Ethylene is the plant equivalent of a scream," says Murch. But Baluska goes a step further, pointing out that the gas is produced in large quantities by fruit when it's ready to be eaten. "If you consider ethylene as an anaesthetic, and if some organism is producing an anaesthetic under stress then you could get ideas that plants maybe feel some pain," he says.

Such notions are extremely controversial and, even Baluska agrees, speculative. To avoid simply pitting one side against another in the debate, we need a different framework to start thinking about notions of intelligence and consciousness, says Michael Marder of the University of the Basque Country in Vitoria-Gasteiz, Spain. The lone plant philosopher for now, he argues for a phenomenological approach to understanding plants, which involves asking: what does the world look like from the standpoint of plant life?

"Our task is to think about these concepts of attention, consciousness and intelligence in a way that becomes somehow decoupled from the figure of the human," he says. "I want [us] to rethink the concept of intelligence in such a way that human intelligence, plant intelligence and animal intelligence are different sub-species of that broader concept, which can somehow encompass these different life forms."

Murch has begun engaging with such questions in one of her classes, which brings together biochemistry and creative writing students to ponder plant intelligence. "Inevitably, there is a vegan in the audience who goes, 'Then what will I eat?'" she says.

That might seem like a flippant response, but contemplating whether plants are intelligent could lead us to change the way we live. As Marder points out, the sessile nature of plants means they don't exist in opposition to the place they grow. Rather, they become a focal point for myriad organisms. "Maybe we can use that model for ourselves, to temper a little bit the excessive separation from our environment that has led in large part to the profound environmental crisis we find ourselves in," he says. ■

The Venus flytrap remembers a touch and only snaps shut if touched again within 30 seconds

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Anil Ananthaswamy is a consultant for *New Scientist*

CEREAL KILLER?

You could be consuming far too much iron. ***Liz Bestic*** *investigates*

NEXT time you are in a supermarket, take a closer look at the bread you buy or your cereal packet – you might be surprised to see how many of these staples are fortified with iron. In fact, cereal products make up a whopping 45 per cent of our average daily iron intake.

That may seem like a good thing, if it wards off iron deficiency and anaemia. But evidence is emerging that decades of fortifying food with iron and regularly popping supplements could be leading people to ingest more iron than they need.

While the effects of this overload are still up for debate, some scientists believe that it could be damaging our health – and the prevalence of diseases like diabetes and heart disease could be a symptom of this excess. What's more, too much iron seems to be a source of cancer-causing free radicals.

"Iron overload degrades the chemical structure of DNA, predisposing us to everything from heart disease and stroke to diabetes and obesity," says Leo Zacharski at Dartmouth-Hitchcock Medical Center in Lebanon, New Hampshire. "It's a far stronger risk factor than smoking for all sorts of clinical disorders."

The primary use of iron in the body is in haemoglobin proteins, the part of red blood cells which carry oxygen to tissues. If you don't have enough iron in your body, because there's not enough in your diet or you can't absorb enough from your food, you might have shortness of breath, fatigue, and cognitive and immune problems.

The most severe form of iron deficiency, anaemia, affects 2 billion people worldwide, especially those in developing countries. It is also common among pregnant women.

The issue came to the fore in Europe and the US during the second world war when rationing left large swathes of the population malnourished. The response of governments was to increase the iron content in staples like flour and cereals, to make sure people got enough in their diets. The policy was widely extended to infant formula, and since the 1970s, pregnant women in the US have also been prescribed iron supplements. Today, many of us buy these over the counter. Forty per cent of Americans take supplements which contain iron, often unaware that many of these contain more than twice the amount of iron recommended for an entire day.

At that time, though, not everyone was convinced of the benefits of boosting the amount of iron in the diet.

Iron deficiency anaemia is now rare in the West, but might we be getting too much of a good thing? More than 30 years ago, Jerome Sullivan, then a researcher at the University of South Florida in Tampa, was puzzled by the fact that women don't tend to suffer from heart attacks until after the menopause, during their late 40s or early 50s, whereas rates in men rise during their 30s.

He wondered whether the ›

ALL PICTURES GETTY

Those at risk of overload

The genetic disease haemochromatosis causes the body to absorb too much iron, and is underdiagnosed in the general population. Also at risk are those with a history of taking iron supplements, heavy or binge drinkers, and people with diabetes or chronic inflammatory conditions such as arthritis

Types of iron

How much iron the gut absorbs largely depends on its chemical structure. Iron in red meat, fish and poultry is mainly haem iron, and is absorbed more easily than the non-haem iron found in plant foods. Between 10 and 20 per cent of the iron in animal foods is absorbed, and between 1 and 10 per cent of that in plant foods

Menu minefields

Some foods can change the amount of iron you absorb from a meal. Eating 75 grams of cooked meat with iron-rich vegetables will increase the amount of the iron you take in from the vegetables. Drinking tea or coffee with, or up to an hour after, a meal can reduce iron absorption by 60 per cent

How to balance your iron

A study of 29 US breakfast cereals found that they tended to contain significantly more iron per portion than stated on the pack...

TOO LITTLE

Number of people worldwide who are anaemic

2 billion

Percentage of girls aged 11 to 18 who do not get enough iron (UK)

46%

TOO MUCH

People with genetic iron overload disease haemochromatosis

1 in 200

People taking iron supplements, many unnecessarily (US)

40%

+ Things that increase iron absorption

Oranges, kiwis, carrots, tomatoes, red grapes, peaches, prunes, honey, alcohol

*...on top of this, **men** serve themselves three times as much as is recommended (75g)*

***Women** serve themselves twice as much (66g)*

RDA

(US)

MEN	WOMEN
8mg	18mg

Recommended daily allowance for vegetarians is 1.8 times higher than for people who eat meat

- Things that decrease iron absorption

Blueberries, spinach, eggs, milk, walnuts, coffee, chocolate, tea, wheat bran, strawberries, herbs

Source: Iron Disorders Institute

SPINACH

Popeye was wrong – most of the iron in spinach can't be absorbed by the body

GUINNESS

You'd need to drink 16 pints to get the same iron found in 1 pint of orange juice*

A BOILED EGG

One egg can reduce the iron absorbed from a meal by 28 per cent**

**Source: Talanta, vol 57, p 45*
***Source: American Journal of Clinical Nutrition, vol 71, p 1147*

"Too much iron from supplements can cause our organs literally to rust"

menstrual loss of iron in pre-menopausal women had any a protective effect. Sullivan published this "iron hypothesis" in 1981 in *The Lancet*.

The idea was backed up by research at the time showing that populations with lower levels of iron in their blood and cells had low rates of heart disease. But these signs were largely ignored against a backdrop of decades of iron fortification.

Bad behaviour

Today, concerns are growing that population-wide fortification policies have been overzealous , supporting what some physicians argued at the time. "In the US it was not the medical doctors who pressed for supplementation, but nutritionists," says Andrew Ghio, a medical officer at the US Environmental Protection Agency in Washington DC. "The physicians suggested using iron in a select group of patients who are iron deficient and that there was no need to provide iron on a population-wide basis."

They might have been on to something. Support has been trickling in for Sullivan's hypothesis that too much iron could be bad for the heart. At the time, he suggested that an excess of iron could cause the walls of arteries to narrow and harden, a condition known as atherosclerosis.

That idea was put to the test when Hidehiro Matsuoka, at the Kurume University School of Medicine in Japan, injected 10 healthy men with high levels of iron and used ultrasound to monitor changes in their blood vessels. The injections caused the vessels to constrict, leading Matsuoka to believe that iron excess could be the first step in a cascade of events leading to atherosclerosis. Other work has found high levels of iron in the blood and arteries of people with diseases of the heart, including atherosclerosis and angina. This doesn't prove that iron is the cause, but does hint at a connection.

And heart health is just the start. One of today's main proponents of the iron hypothesis is Douglas Kell at the University of Manchester, UK. He reviewed more than 2000 scientific papers examining iron and disease and concluded that iron overload contributes to a host of today's most common illnesses (*BMC Medical Genomics,* DOI: 10.1186/1755-8794-2-2).

Why might this be? It could be because even though iron is essential to life, it is also toxic. To make it less harmful, most of the iron we absorb from food gets bound to proteins, mostly those involved in the transport of oxygen, such as haemoglobin. Excess iron gets stored in a protein called ferritin, which is especially abundant in the liver, spleen and bone marrow.

Kell suggests that the problems arise when this system goes wrong. As long as the iron remains locked up with these proteins, there's no problem, but if it is released then iron begins to behave very badly indeed.

This "free iron" is dangerous because it reacts with the everyday products of cell metabolism to produce highly reactive molecules known as free radicals. These can wreak havoc in the body, damaging parts of the cell they come into contact with, including DNA.

Some of the strongest evidence for the damaging effects of free iron comes from people with a genetic disorder called haemochromatosis. They absorb too much iron from their food, because the condition disrupts the signalling of a hormone called hepcidin. The hormone usually stops the gut absorbing excess iron and makes sure that when immune cells known as macrophages digest old red blood cells, the iron stays locked inside the macrophages and out of harm's way. In people with haemochromatosis, macrophages and cells that line the gut dump iron into the circulation. And between 30 and 60 per cent of them develop type 2 diabetes.

The increased risk doesn't seem to be unique to this group. The most compelling indication comes from a study of nearly 10,000 US adults, which found that high levels of the iron-storing protein ferritin in the blood – a common test for iron levels – were associated with a nearly fivefold hike in the chances of men getting diabetes, and a 3.6-fold increase for women.

x1.8

HOW MUCH MORE IRON VEGETARIANS SHOULD EAT

SUSUMU NISHINAGA/SCIENCE PHOTO LIBRARY

Locked up in red blood cells, iron helps carry oxygen around the body

So if systems are in place to keep iron safely bound up, what's the risk to most people? Many of the diseases that Kell's review found to be affected by iron overload, which include cancer as well as type 2 diabetes and heart disease, are increasingly being linked to inflammation. Kell and the other supporters of the iron hypotheses believe this is no coincidence.

Inflammation is the normal immune response when the body comes under attack from foreign invaders, but it is also caused by the everyday wear and tear that comes with ageing. And it seems to affect how our bodies handle iron.

In the short term, inflammation can cause iron to be even more tightly locked away. This is probably an evolutionary adaptation, designed to stop bacterial invaders, which need iron to survive.

But prolonged inflammation triggers the death of the macrophages and other cells that keep iron locked up. This leads to a spiral of destruction as the free iron produces more free radicals. "The more iron you have in your body, the more hydroxyl radicals are potentially being produced, which in turn triggers more inflammation," says Kell.

This surge of free radicals, which play a part in causing cancer, is one explanation for

various studies implicating iron overload in common cancers such as those of the lung, colon, bladder and oesophagus. It could also explain why people with haemochromatosis have an increased risk of developing cancer of the liver – where most of the body's iron is stored.

There may be other mechanisms at work. Like bacteria, tumour cells need iron to thrive, and feeding iron to such cells in a Petri dish makes them grow and multiply faster. There are also indications that high levels of iron switch on a key cancer signalling pathway and could raise the risk of bowel cancer.

Not everyone supports the iron hypothesis, though. "People who work in this area are very conflicted about it," says Tomas Ganz of the University of California, Los Angeles. His team gave supplementary iron, by food or injection, to mice that were genetically susceptible to atherosclerosis, and found no difference in the development of plaques compared with control mice that didn't receive iron.

Ganz thinks it is impossible to disentangle the role of iron from other elements of the diet. "The epidemiological evidence for an increase in diseases like atherosclerosis, heart disease and diabetes being associated with high iron levels is weak," he says.

There is also disagreement about whether action should be taken. Some countries, like Denmark and Sweden, have now stopped the practice of adding iron to flour. But last year, the UK government published a report on the fortification of bread and flour, and concluded that legislation should stay as it is. The report said that while some studies show an association between iron intake and cardiovascular disease, this could be attributed to other things, like fat in meat.

Even if you suspect you are overloaded with iron, it's often hard to tell. Key symptoms, such as lethargy, are the same in iron deficiency and overload. It's hard to measure too, mainly because iron can accumulate in specific tissues, so might not show up in a blood test.

To get around these issues, imaging techniques are being developed that could quantify iron levels in specific tissues. Until then, those worried about the potential health risks can take steps to protect themselves. For a start, avoid iron supplements unless absolutely necessary. "Nobody should be taking iron supplements without the advice of a doctor," says John Porter, a consultant haematologist at University College Hospital, London.

"Too much iron in the form of supplements can accumulate in our tissues causing our organs literally to rust," says Zacharski.

The solution might be as simple as giving blood. Giving blood reduces iron levels, because some of the iron stored in the body is used to make replacement haemoglobin. "It's a neat solution to a huge public health problem," says Zacharski.

Another option is to monitor dietary consumption of iron more carefully. For most people, the chances of overloading through food alone are slim. But some people are at higher risk. Knowing how much the body needs and how much you can get from various foods is wise (see page 39).

It is also worth considering that many foods, even those rich in iron themselves, contain compounds that inhibit or increase iron absorption. For example, washing down a hamburger, string beans and mashed potato with tea or coffee, rather than water, can reduce how much iron is absorbed from the meal, whereas if you sip orange juice it can boost absorption by 85 per cent.

There might be times when an iron boost is required. For instance, when levels fall temporarily during menstruation, an orange juice might be just the ticket. Those overdoing the red meat, though, might be better off ordering a green tea.

Of course, for many people, such a variety of foods isn't an option. For them and for those with clinical deficiencies, supplements and fortification still have a crucial role to play. But most Westerners have a plethora of choices when it comes to treading the fine line between too little and too much iron. Knowing about small dietary tweaks such as switching drinks could help you gain control. For once there a good excuse to play with your food. ■

Liz Bestic is a freelance health writer based in London

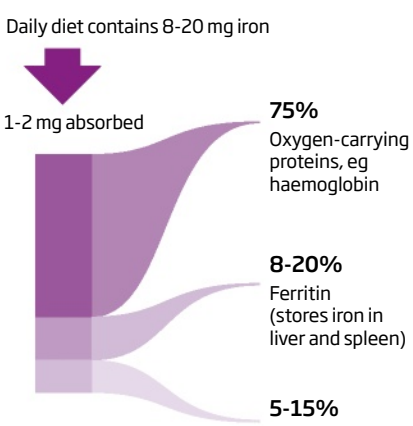
ANDY KIRBY/GETTY

7.2m

UK IRON SUPPLEMENT PRESCRIPTIONS IN 2013

Where the iron goes

Iron is transported around the body by a carrier protein called transferrin until it reaches its destination



SPENCER WILSON

BY JUPITER, WE REALLY CAN GO TO EUROPA

Move over space agencies, we're launching our very own craft to explore Europa. **Michael Brooks** invites you along for the ride

WE'RE normally a patient lot at *New Scientist*. We know science takes time. Even so, we've been reporting on the possibility of life on Europa, Jupiter's ice-encrusted moon, since the mid-1990s. Now, two decades on, we're facing another 15 years or more until NASA or the European Space Agency visit it with a spacecraft capable of telling us more.

Frankly, we just can't wait that long to see what's out there. So we thought, why wait at all? It's the 21st century. Who leaves it to governments or international space agencies to fulfil their dreams? This is the age of do-it-yourself, crowdsourced everything. Hence the *New Scientist* mission to Europa. You're welcome.

To the untrained eye, Europa looks like a wildly expensive destination. ESA's Jupiter Icy Moons Explorer mission, or JUICE, will make two dedicated fly-bys at an estimated cost of €1 billion. True, that includes a look at Jupiter, Callisto and Ganymede, but still. The price tag on NASA's proposed Europa Clipper mission is just as high.

Given these eye-watering estimates, you might be doubting whether anyone can crowdfund a space mission. Hey, it's already been done. It's exactly how more than 2000 space enthusiasts raised upwards of $160,000 to reboot an old NASA solar explorer mission called ISEE-3. It was enough for NASA to hand control of the craft to the rebooters. And not reluctantly, either: in September, NASA issued a report called "Emerging Space" that acknowledged the power of crowdfunding for space missions and called it "a way to have citizens participate with NASA in a way never before possible". Thanks to platforms like Kickstarter and Rockethub, there is "an opportunity for Americans from all walks of life to be an integral part of NASA's team".

But maybe you're not American. Maybe you don't want to be on NASA's team. Maybe you want to be on Team New Scientist. You will when we tell you our craft's name. Let's hear it for TEENSY: the Tiny Europa Explorer by New Scientist and You.

You want some background before signing up? Well, there are good reasons to go to Europa. For a start there's liquid water, lots of it. Starting with a few hints in early magnetic field measurements and progressing to certainty thanks to the Hubble Space Telescope, we now know it is there beneath the moon's icy crust. No one is sure how deep the ice goes; it could be just a few kilometres thick, or anywhere up to 30 kilometres. But beneath it sits a huge ocean. Not only is it roughly twice the volume of Earth's oceans, there's evidence that these seas could contain the ingredients for life.

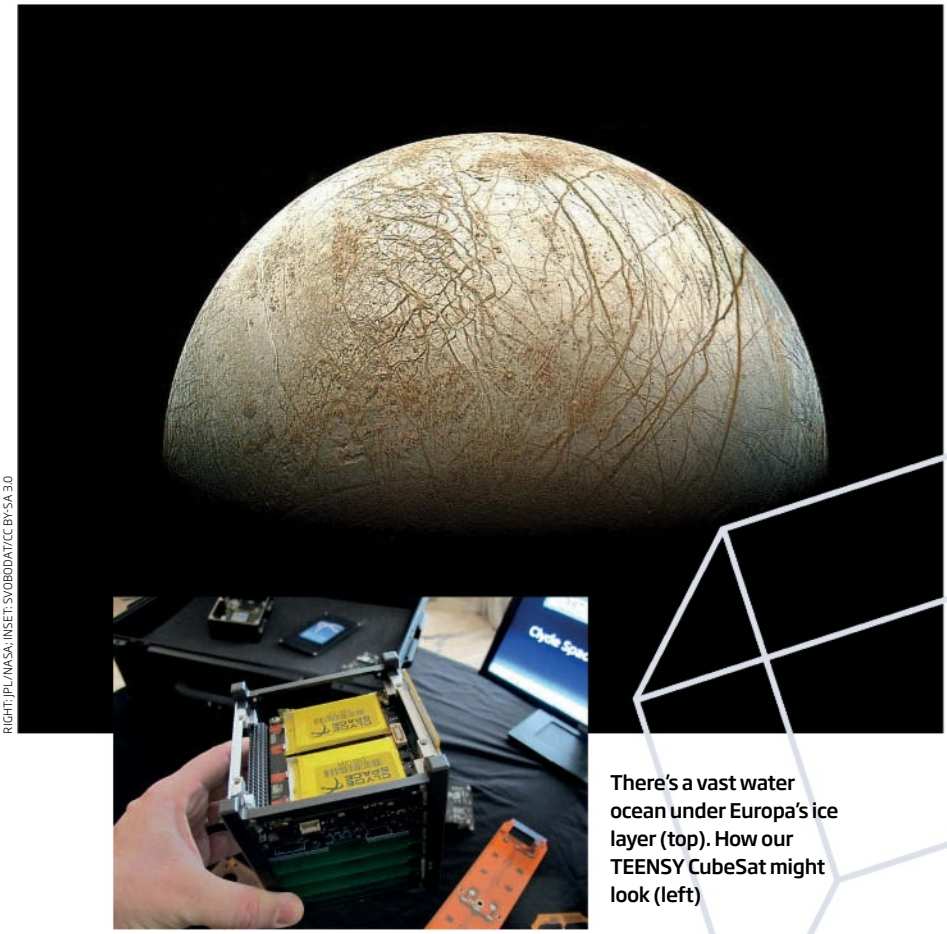
That comes from the curious criss-cross of scars on the moon's surface that are believed to be a result of Jupiter's gravity stretching and squeezing it. That creates heat, causing ice to melt and refreeze, and also generates convection currents in the water. This circulation would drag minerals up from the moon's silicate mantle, producing a mix of chemicals that could nurture life. The moon even has a thin, oxygen-rich atmosphere that could help sustain living creatures and make Europan life not dissimilar to that of primordial Earth. "It is a very good candidate when thinking of habitability or the existence of 'life' beyond the Earth," says Emma Bunce of the University of Leicester and a member of the JUICE science team.

And, amazingly, we might not even have to go under the ice crust to find it. At the end of last year, Hubble recorded images of vast water plumes shooting into space. The plumes were 200 kilometres high and our best estimates suggest that they fire out 3000 kilograms of water every second. That means if there is life in the Europan oceans, it could be detected by intercepting the plumes in a passing spacecraft. Our passing spacecraft. Surely you want to be involved with the first craft to fly through a water jet teeming with alien life?

Small is big

You're probably wondering whether TEENSY could possibly do such amazing things, given – as the name suggests – its diminutive size. Not a problem: in space travel, small is the new big.

We're talking CubeSats, standardised 10-centimetre cubic modules for building spacecraft. Their creators at California State University Polytechnic have been astonished at their popularity. CubeSats have been used to sample Earth's atmosphere, monitor shipping and help detect earthquakes; more than 100 little boxes have been launched so far, and scores of missions are under construction. There are even stores, like the one run by Clyde Space, a CubeSat designer and manufacturer in Glasgow, UK, that allow you to pick and ›



RIGHT: JPL/NASA; INSET: SVOBODAT/CC BY-SA 3.0

There's a vast water ocean under Europa's ice layer (top). How our TEENSY CubeSat might look (left)

mix your components. "The technology is very well suited to a range of applications," says Chris Brunskill of the Satellite Applications Catapult, a UK company that helps businesses take advantage of the country's growing space industry.

Their appeal lies in the standardisation: you stuff the cubes with cheap, off-the-shelf components that will perform a unique task. But externally they are all identical, which makes launch easy and reliable – even if you choose to connect two or three together, as is now becoming common. "You can go to a launch provider with a CubeSat and they know there'll be no issues, which is very different from a bespoke satellite," Brunskill says.

Traditional launch is on a rocket equipped with a Poly-PicoSatellite Orbital Deployer, or P-POD. Once in low Earth orbit, it throws a bunch of CubeSats out into space to do their work. There's a new alternative, though – you can put your CubeSat on a Soyuz or SpaceX craft bound for the International Space Station. There, an astronaut will kick it out into space for you.

It's surprisingly cheap. We've been told it will cost about €130,000 to have an ISS astronaut throw a couple of kilograms out of the airlock. *New Scientist* has over four million readers worldwide; divided between us that's pennies.

Of course there's the 500 million kilometre plus journey to Jupiter. This is a new frontier for CubeSats: the standard procedure is for the module to sit in low Earth orbit for just a few days before it is allowed to fall back to Earth.

But moving away from Earth shouldn't be a problem. As for a propulsion system, "If you have a can of deodorant – some kind of pressurised canister – that's essentially it," says Adam Masters of Imperial College London, who's also on the JUICE team.

Mission control

We can probably do a bit better than a spray can. Take Benjamin Longmier's CubeSat xenon engine, for example. Longmier, who works at the University of Michigan, starts his engine by ionising xenon gas to form a plasma. Once that plasma has formed, an electric field accelerates it towards the back of the CubeSat, pushing the craft forward.

Longmier's thrusters give about 10 watts of power. It's not a lot – about two cellphones' worth, as he puts it – but it would be enough to get to Europa eventually. About a year after a launch into a low Earth orbit, it would be capable of around 17 kilometres a second. "That means it could go just about anywhere in the solar system," Longmier says.

An alternative would be Martin Tajmar's field emission electric propulsion engine. It uses liquid metal as a propellant and is just 1 centimetre in diameter. "You apply a voltage and it generates an ion beam," says Tajmar, who works at the Technical University in Dresden, Germany. "It's small but highly capable: you can generate thrusts from a few microNewtons to tens of microNewtons. For a small satellite this is a lot."

One advantage is its efficiency – more than 90 per cent of the propellant generates thrust. "That's an order of magnitude above pulse plasma thrusters," Tajmar says.

So better than a spray can, then. But is it better than the hot new technology of solar sailing? This uses nothing more than the gentle pressure exerted by sunlight to cruise through space. With a solar sail, there's no propellant to carry and no worries about it running out.

The power does diminish as you get further from the sun, but if TEENSY has already accelerated to the speed it needs, there's nothing to stop it sailing on to Europa, in theory. The Japanese IKAROS probe has already shown that solar sailing to another planet is possible. Although not a CubeSat, it glided past Venus in December 2010 and is still on its way through the solar system.

A CubeSat could set sail, too. If the Planetary Society can successfully crowdfund its module, it is scheduled to launch in May 2016 and it will have four ultra-thin mylar sheets that unfurl beyond low Earth orbit. "Sending a CubeSat to Jupiter is not unrealistic," says Apostolos Christou of Armagh Observatory in the UK, "but you do have to be innovative." He estimates that TEENSY could reach Jupiter in 5 to 10 years.

So we have power to boldly go, but nobody has operated a CubeSat in deep space. Can it be done? The people behind NASA's INSPIRE mission think so. It has no launch date as yet, but INSPIRE aims to demonstrate that a CubeSat can communicate, navigate and perform useful functions beyond low Earth orbit. "We have a mission objective of reaching at least 1.5 million kilometres," says mission leader Andrew Klesh. "Our minimal objective is 400,000 kilometres, that's lunar distance from Earth."

So far, so good. Assuming TEENSY can get from the drawing board all the way to Europa, what equipment should she be carrying?

The big space agencies have already

outlined what they'd like to do. Their list includes examining what Jupiter's radiation does to the Europan environment; measuring the thickness of the ice crust and examining its surface features; identifying a suitable landing site for a future mission and, of course, sampling the ocean.

The kind of tools needed for these tasks are quite daunting – and heavy. So far, 11 have been selected by the big missions. Among them are: an ice-penetrating radar, an infrared spectrometer, a topographic imager, a mass spectrometer, a magnetometer, an antenna for radio gravity tracking, a high resolution camera and a thermal imager.

It's hard to imagine packing all that into a CubeSat. So we are going to have to make some difficult decisions.

The ideal ice-penetrating radar, one that can see at depths of 30 kilometres, has a mass of 42 kilograms. A bit big, then. Even if we downsize to one that penetrates 3 kilometres, according to Van Kane, who blogs for the Planetary Society, it would still be 12 kilograms. So maybe we could leave measuring the thickness of Europa's ice crust to the latecomers.

Likewise with an infrared spectrometer for examining the composition of the icy surface, which weighs in at 19 kilograms. But a mass spectrometer, to analyse molecules captured from a plume of water and gas, could require as little as 7 kilograms of the allowance. That seems OK. We could couple that with a 4-kilogram camera – sorry, topographic imager – that will give us close-up pictures of the surface and maybe show where a future mission could land.

> ***"Surely you want to be involved with the first craft to fly through a water jet containing alien life"***

So, with 11 kilograms of instruments we could hope to encounter a plume for analysis, and photograph the moon's surface. And that's just with the kit around at the moment. "There's a lot of drive to make instruments smaller, motivated by the potential of the CubeSat platform," says Masters.

Flagship missions like Europa Clipper and JUICE have to use tried and trusted, entirely reliable technology. But we could gamble, and take something like MAGIC, the tiny magnetoresistive magnetometer developed by researchers at Imperial College London to measure the magnetic field in low Earth orbit. It's not quite up to the sensitivity we'd want for Europa, but it has already seen service aboard CubeSats and there's still time to develop it further before launch.

We're confident we can get some useful instruments on board, then. There is just one problem remaining. How are we going to find out what TEENSY has discovered?

"Communication from there back to Earth? With an antenna the size of a pencil?" Tajmar actually laughs out loud at the idea. "Not a chance!" he says. This could be a fatal flaw. Klesh has thought this issue through for the INSPIRE project, and doesn't exactly inspire confidence. "Our communications link holds strong well past 1.5 million kilometres, but we will reduce our data rate accordingly as we get further and further away," he says. After that, they will only send what is absolutely critical. "At some point, we will drift further away from Earth than we might be able to communicate, but this will be well beyond our mission objectives." Those objectives, remember, top out at 1.5 million kilometres. Europa is nearly 400 times that distance from Earth.

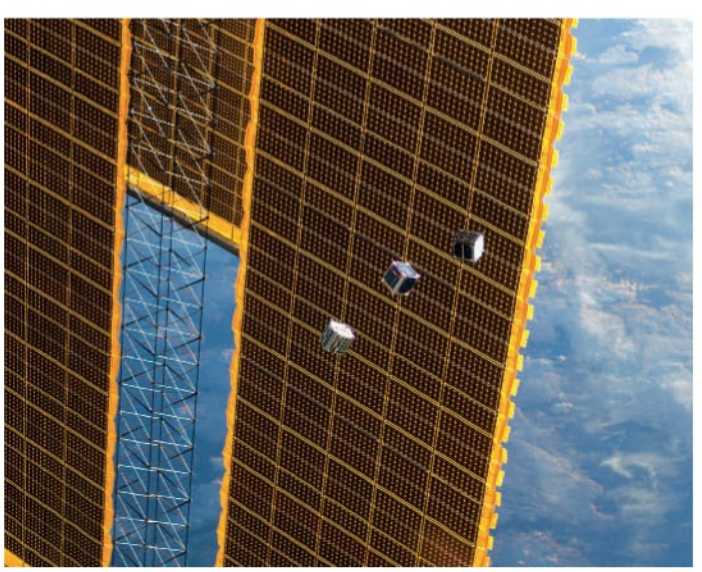
Strength in numbers

We could rely on the rapid rate of progress in CubeSat and space technology to come to our rescue, but really, we can't stake everything on that. We have to find a realistic solution – and there is one. It's not ideal, but it looks like the only option at the moment. We have to wait for NASA to arrive at Europa, with CubeSats.

In October, the Jet Propulsion Laboratory in California announced it was considering taking an extra load aboard the Europa Clipper: a bunch of CubeSats that would swarm around the moon making measurements from multiple views. Although there's no guarantee any CubeSats will make it onto the Europa Clipper, they are worth investigating, says project manager Barry Goldstein. "They've been showing significant promise in their ability to adapt for deep space missions," he says. "That doesn't mean we've proven it, but it's certainly a good thing to have in your hip pocket."

If they make it on board, those sats will have to upload their data to the Clipper, which would have a powerful enough antenna to beam it all back to Earth. And if NASA's CubeSats can talk to the Clipper, so can ours.

As soon as the mothership arrives, TEENSY can wake from an energy-conserving hibernation and relay our hard-won data back to Earth. That can happen before the Clipper mission has gathered a scrap of its own data. So, although we would be later than we'd like in delivering the news of life on Europa, our TEENSY would still be the first to detect it. That's good enough, isn't it? Who's in? ■



NASA

CubeSats can be launched from the International Space Station

Michael Brooks is a consultant for *New Scientist*
Follow TEENSY on twitter @TEENSYmission

The deepest limits

The first thing Jacques Piccard saw on reaching the very bottom of the Pacific Ocean was a flatfish. But fish can't live that deep, **Sandrine Ceurstemont** discovers

IN 1960, when Jacques Piccard made his epic dive to the deepest part of the ocean, 11 kilometres below the surface, he spotted a flatfish on the sea just as the submersible was about to touch down. "Just beneath us was some type of flatfish, resembling a sole, about 1 foot long and 6 inches across. Even as I saw him, his two round eyes on top of his head spied [us, and] extremely slowly, this flatfish swam away," Piccard wrote in his book *Seven Miles Down*. "Moving along the bottom, partly in the ooze and partly in the water, he disappeared into his night."

Seconds later, the submersible stirred up the sediment as it touched down. Piccard and Don Walsh saw nothing but milky murk for the rest of the 20 minutes they spent at the bottom of the Challenger Deep – the lowest part of the Mariana Trench – so much was made of the flatfish sighting. "Here, in an instant, was the answer that biologists had asked for the decades," Piccard wrote. "Could life exist in the greatest depths of the ocean? It could!"

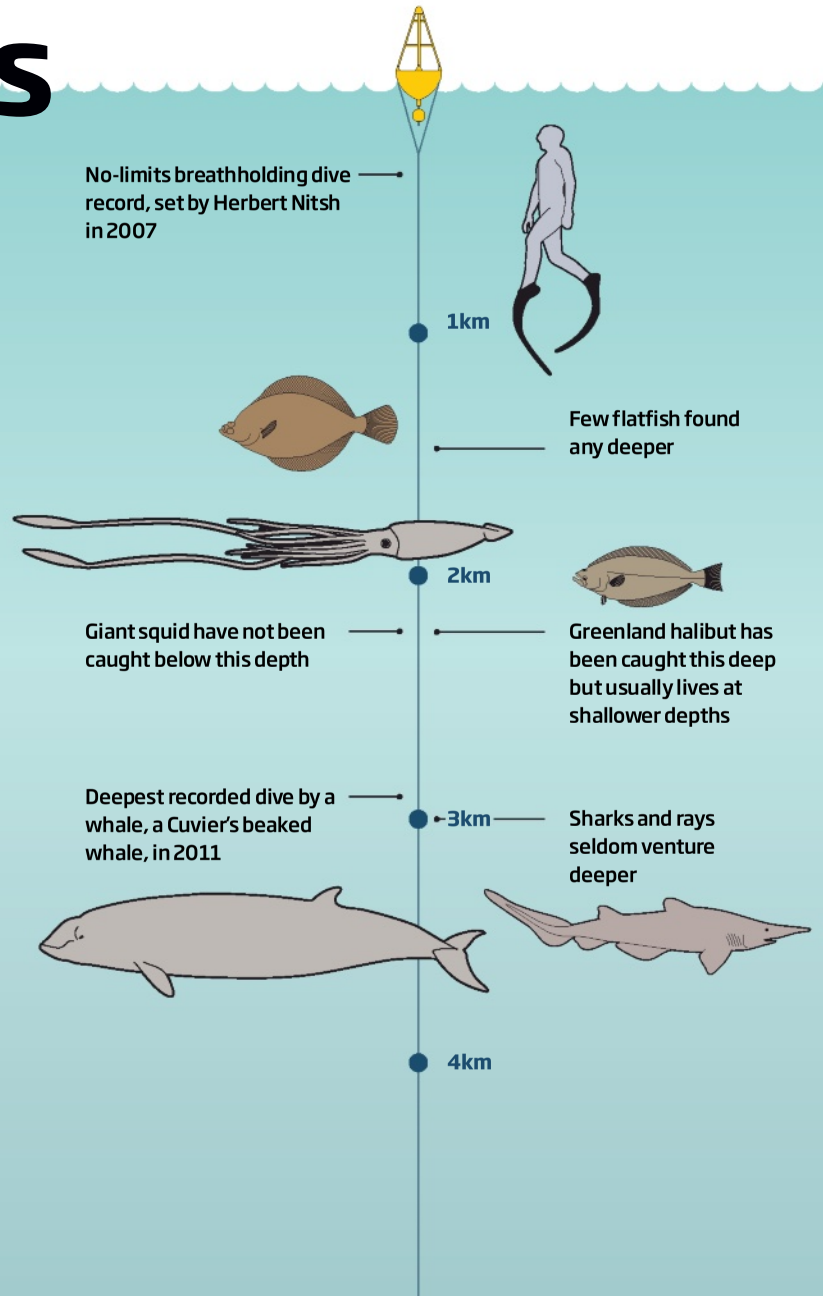
To this day, the sighting is still occasionally cited as evidence that fish exist in the deepest parts of the ocean. But even at the time, marine biologists suspected that Piccard was mistaken. They knew that no fish had ever been caught much deeper than 7.5 kilometres down.

TMAO is found in many marine animals. In fact, the characteristic smell of fish comes from the breakdown of TMAO. In shallow-living fish, TMAO helps regulate the concentration of dissolved substances in the fluid inside cells. Crucially, though, it also helps proteins keep their shape. This means fish can keep all their proteins working as they go deeper simply by increasing the concentration of TMAO in their cells.

Levels of TMAO aren't only higher in deep-living fish species, but also in deeper-living individuals. "They accumulate more TMAO with depth," says Mackenzie Gerringer of the University of Hawaii, who studies abyssal and trench fish. This may be what allows some fish, such as the abyssal grenadier, to move thousands of metres deeper as they get older.

But there is definitely a limit to how deep fish can go. The cusk eel is often cited as the deepest fish, because one was caught in 1970 during a trawl at a depth of 8370 metres. Since no others have been found so deep, though, biologists now suspect it was caught as the net was being raised or lowered.

The undisputed record for the deepest living fish is held by the snailfish *Pseudoliparis amblystomopsis*, filmed 7703 metres down in 2008 by an expedition led by Jamieson.



More recently, biologists such as Alan Jamieson have sent cameras to the bottom of the deepest trenches and captured hundreds of hours of film footage. No living fish has ever been spotted deeper than 7700 metres down. "Suddenly they disappear," Jamieson says. "Their cut-off point seems very distinct across all trenches examined." The question is why. And he and his colleagues at the University of Aberdeen think they have the answer.

Extreme conditions

Down in the abyss, conditions are extreme. It is dark, cold and, apart from the occasional bonanza like a dead whale, there's little to eat. Many fish stick to shallow water. Sharks and rays in particular are extremely rare below 3000 metres. There simply may not be enough for them to eat at extreme depths, says Monty Priede also at the University of Aberdeen. Whereas other fish have an air-filled swim bladder to keep them afloat, sharks depend on fatty food to maintain a huge, oily liver that keeps them buoyant. "Using fat as buoyancy is a massive energy penalty," says Priede.

The greatest challenge in deep living, though, is the extraordinary pressure. At the bottom of Challenger Deep, it is equivalent to having two elephants standing on your big toe. This has a profound effect on the body. Shallow-living animals cannot simply move deeper at will – at a certain point, their muscles and nerves would stop working.

At high pressures, for instance, the fatty membrane of cells becomes stiffer, impeding normal function. To compensate, deep-living species increase the proportion of viscous fatty molecules to keep the membrane fluid.

High pressure can also alter the shape of proteins, which is a huge problem because the workings of proteins – including the enzymes that catalyse reactions vital for life – depend on their precise shape. One way to adapt is to tweak each individual protein to work at depth. But deep-sea fish have come up with a more general and flexible solution: a chemical called trimethylamine oxide, or TMAO.

The reason fish can't live much deeper than this, might be to do with TMAO, suggested Paul Yancey of Whitman College in Washington a few years ago. Higher levels of TMAO make the fluid inside cells more concentrated. Deep-sea fish, however, have to keep the concentration of the fluid inside their cells at or below that of seawater to survive. At a certain depth, then, cells won't be able to accumulate any more TMAO.

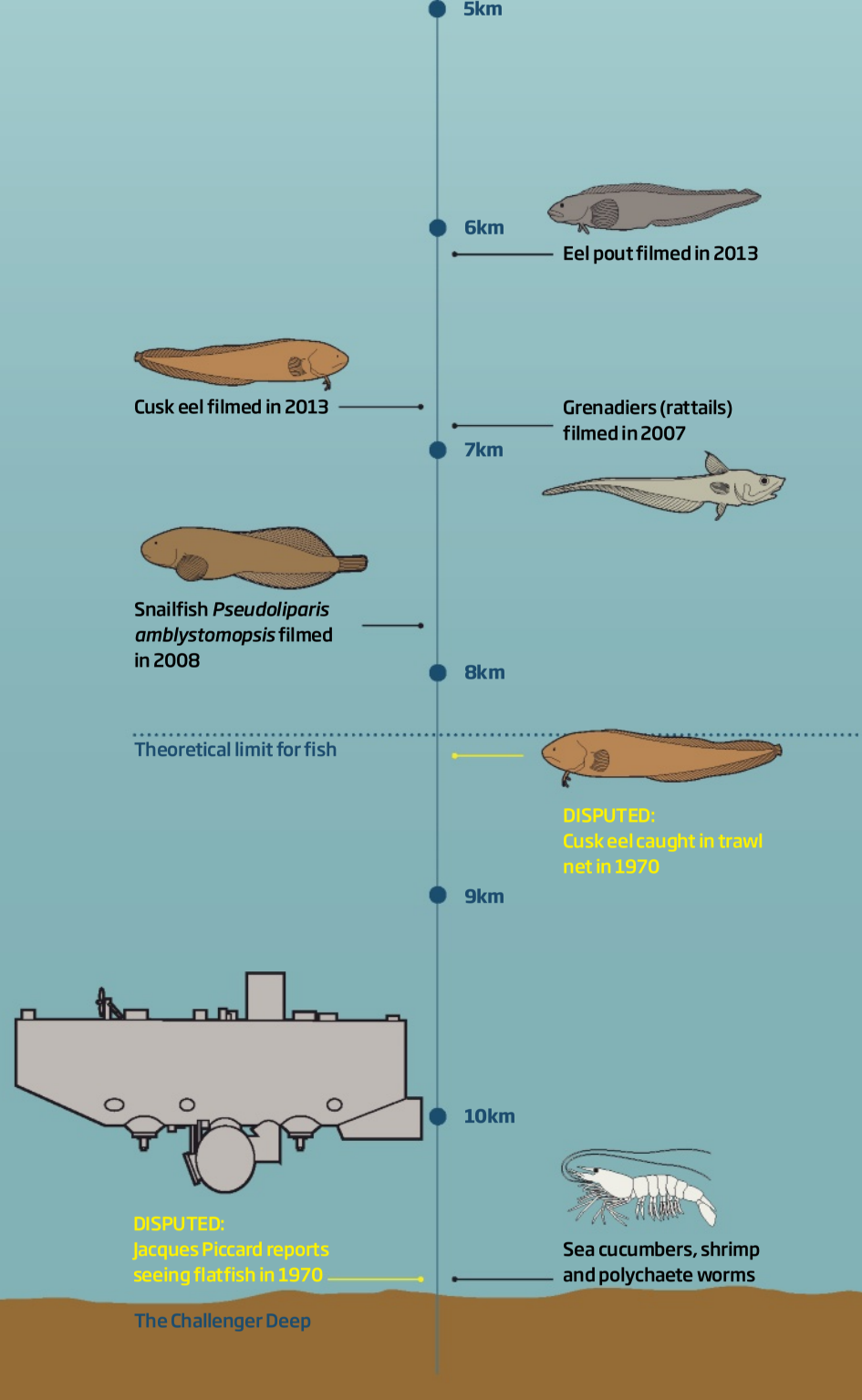
To test this idea, Yancey and Jamieson looked at TMAO concentrations in several fish species caught at various depths. Some were frozen specimens from other expeditions but the team also caught some *Notoliparis kermadecensis* snailfish – the second-deepest species ever seen alive. TMAO concentrations increased proportionally with pressure, pointing to a theoretical limit at about 8200 metres, they reported earlier this year (*PNAS*, vol 111, p 4461).

That fits in neatly with the actual observations. "All things fell on the magic 8000 metres mark," Jamieson says.

While the deepest parts of the ocean are devoid of fish, we now know they harbour many other animals, such as woodlice-like amphipods. Among other things, an unknown kind of sea cucumber has been spotted in footage from James Cameron's 2012 dive to the bottom of the Mariana Trench – and it has been suggested that Piccard mistook some kind of swimming sea cucumber for a flatfish. How these animals survive the immense pressure isn't known. "They may be doing something completely different," says Jamieson.

Are there any ultimate limits? Could life exist even at the greatest depths of oceans on other planets? Europa's ocean is thought to be 800 kilometres deep, for instance. "The biochemistry that we find here on Earth may not apply at all to biochemistry that evolves on another world," says Yancey. "So I don't think we have any way to guess how deep animal life could live." ■

Sandrine Ceurstemont is a video producer at *New Scientist*



Not written in the sand

From technical fixes to really listening to Earth's peoples, there are ways to avoid eco-apocalypse, finds **Fred Pearce**

Dodging Extinction: Power, food, money, and the future of life on Earth by Anthony D. Barnosky, University of California Press, $29.95/£19.95

The Edge of Extinction: Travels with enduring people in vanishing lands by Jules Pretty, Cornell University Press, $27.95

THE end may be nigh, but there are different ways to stave off the extinction of species, ecosystems and ourselves in the 21st century. Two new books capture this perfectly. In *Dodging Extinction*, US palaeontologist Anthony Barnosky champions can-do technical fixes. In a different camp is UK environmental scientist Jules Pretty. In *The Edge of Extinction*, he argues that, as John Lennon put it in another context, we had better free our minds instead.

I would say we need both approaches. And I would like to think that in a few weeks, a well-known online seller will note that people who bought the one book also bought the other.

Dodging Extinction is a rattling read and punchily packaged. Barnosky's prose is tight and accessible, and it lays the crisis on the line: "power, food and money", he writes, threaten "the future of life on Earth". He offers a simple calculation. For 200 million years, the biomass of megafauna on the planet's land surface remained at around 200 million tonnes, which he considers to be the planet's natural carrying capacity. As recently as 300 years ago, that figure held, although humans and their livestock had become the dominant megafauna.

Since then, however, this biomass has rocketed to 1.5 billion tonnes. We achieved that by tapping the energy in fossil fuels, in the process turning a carrying capacity problem into a climate change problem. Meanwhile, our efforts to grow ever more food and turn nature into money have obliterated ever more species. It means we now stand on the verge of Earth's sixth mass extinction.

So far, so Malthusian. But the notion of dodging extinction is still possible. "People are pretty damn clever," says Barnosky. "We can move the world when we want to." We know how to kick our fossil-fuel habit with low-carbon energy sources. We know how to ramp up agricultural yields. Since 1950, he writes, the area of farmland needed to feed a human has fallen from 1.9 hectares to 0.7 hectares. The profit motive can still come to our aid, he believes. Green economics can stop us wantonly destroying nature and instead pay us to protect it.

But is that enough? Extinction has already developed a fearful momentum, Barnosky concedes. His continued optimism derives in part from his belief in the adaptability of nature. Like us, it has a can-do ethic. And we can help preserve its dynamic, ever-changing Darwinian essence – not by recreating its past, or even preserving its present, but by stimulating its future. We have to nurture nature now.

If Barnosky has an Olympian overview of a planet on the cusp, Pretty starts from a very different perspective. His exploration of "the edge of extinction" is evocative, local and personal. He becomes a modern nomad taking journeys, mostly on foot, to meet those he calls "enduring people in vanishing lands".

"Our efforts to turn nature into money mean we stand on the verge of a sixth mass extinction"

He seeks not wilderness, but landscapes of which humans are an intrinsic part. Places that are "wild and not wild", as he says of his own garden. He is concerned about the extinction of human cultures more than species. His argument is that if we lose our connection to the land, we are lost.

Unusual journeys

Pretty never preaches or prescribes. I only detect anger when he describes how native people have been expelled from their land in the name of protecting nature. But he sure can listen to those peoples.

This is an original set of journeys. There is not a rainforest in sight. He joins the Bushmen in Botswana, but otherwise we find him on the fringes of more familiar lands. He meets gypsies amid the marshlands of England's East Anglia, and talks to the Native American Timbisha in California's Death Valley. He joins the Innu amid the snowfields of northern Canada, and confers with a shaman of the Siberian steppe. In New Zealand he visits the Maoris, and clambers up misty mountains not so far from China's megacity of Shanghai.

"I often rise before dawn," he begins the book. But always his landscapes end up full of people.

CHRISTOPHE COURTEAU/NATURE PICTURE LIBRARY/CORBIS

What kind of future faces peoples like the Bushmen of Botswana?

He takes nature and its interaction with humans where he finds it — good lands and badlands alike. For example, he writes almost as lovingly of tramping the industrial shores of the Thames estuary as of boating among hippos in the Okavango delta, and is as respectful of the "snowbirds" criss-crossing the American West in vast motorised trailers as he is of indigenous Australians traversing the outback following mystical songlines. Snowbirds, it seems, also have their songlines.

There is common ground in these books, but differences are telling. For Barnosky, hunters are the enemy. He talks in terms of fighting a war against poachers. But for Pretty, hunters are part of our connection to nature: "The places with the highest abundances of wildlife have also been where people have gathered from the wild over centuries."

Their different philosophies are reflected in their writing styles. While Barnosky is direct and prescriptive, Pretty is discursive, sometimes rambling, and addicted to the present tense, but always hyper-alert to the landscape and people he is writing about. His writing tingles.

Barnosky wants to spare nature by building an ever more efficient human world. Pretty accepts that we need modern medicines and farms and computers. But he wants us to "bring the wilds inside the city walls", and to share the land with nature. "Our greatest danger," he says, "is that society may reach a point where too few people see the planet as worth preserving." Perhaps, on that at least, both will agree. ■

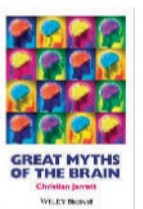
Fred Pearce is a consultant for *New Scientist*

Too simple minds

Why are there so many myths about the way the human brain works?

Great Myths of the Brain by Christian Jarrett, Wiley Blackwell, £14.99

Clare Wilson



THESE days you can't go to a children's birthday party without one of the adults making a knowing comment about the excited scamps being "high on sugar". In fact, there's no evidence that sugar makes children hyperactive. But the remark illustrates the way false beliefs about how our brains work permeate most aspects of life – as does the burgeoning of buzzwords like neuromarketing or neuroleadership.

Such "neurobollocks", to borrow the title of a popular science blog, is ably and entertainingly demolished by Christian Jarrett in *Great Myths of the Brain*. As a journalist in this field, I thought I would know most of these myths, but there was plenty here that was new and interesting to me.

Baroness Susan Greenfield's unscientific scaremongering about computers harming our brains (maybe even linked to a rise in autism spectrum disorders) has been called out before. But it's still satisfying to read such a well researched rebuttal. What evidence there is in this field tends to show the opposite of what she's claiming, writes Jarrett.

Why are there so many myths about the brain? Perhaps because of the growing awareness that this "three pounds of meaty head sponge", as Jarrett calls it, is what makes us who we are. So the lure of simplistic explanations for the way we think, feel and behave can be irresistible, not only to newspapers and TV, but at times to academic journals, the researchers concerned and, yes, *New Scientist* too.

My only quibble with this book is that some of the subject matter took some massaging to fit the myth-debunking format. That said, it was usually an excuse to veer into interesting territory. Whether myth or fact, the science of the meaty head sponge will always be a draw. ■

NICO HERMANN/PLAINPICTURE

Kids high on sugar? Nope, just one of many misconceptions

Evolution in bloom

Darwin would have been amazed by how much we now know about his favourite plants, finds **Adrian Barnett**

Darwin's Orchids: Then & now edited by Retha Edens-Meier and Peter Bernhardt, University of Chicago Press, $55

THERE is a tendency to think of Charles Darwin as a zoologist. Certainly *On the Origin of Species* begins with a long section on pigeons, and animals from the Galapagos played key roles in the great man's thinking about evolutionary processes.

But Darwin was powerfully interested in the botanical side of life. One of his mentors at Cambridge was the notable botanist John Stevens Henslow, and Joseph Hooker, a lifelong friend, was director of the Royal Botanic Gardens, Kew. Of the 10 books that Darwin published after *On The Origin*, six were on botanical topics, and the very first of these was on orchids.

Published in 1862, *On the Various Contrivances by which British and Foreign Orchids are Fertilised by Insects* was partly derived from Darwin's studies, but also brought together the observations of a huge number of people with whom he corresponded. This is a pattern of cooperative science he began when studying barnacles and continued throughout his life.

The 150th anniversary of *Contrivances* was celebrated with a symposium, which organisers Retha Edens-Meier and Peter Bernhardt expanded into *Darwin's Orchids*. The book is divided into the same number of sections as there were chapters in *Contrivances*, with each section dealing with a topic from an original chapter.

CHRISTIAN ZIEGLER/MINDEN PICTURES/FLPA

Display of invention: orchids continue to fascinate us

This allows the book's 30-odd authors to show just how far 150 years of study and thinking have taken us. There are sections on British and European orchids (the fly orchid, *Orchis insectifera*, was Darwin's favourite), orchids from the drylands of southern Africa and Australia, and the extravagant and glorious panoply of rainforest and cloud forest orchids. Finally, just as Darwin did, the book takes a long, lingering look at the pollination biology of slipper orchids, a truly flamboyant group even by the High Baroque standards of the family.

An additional chapter considers the conservation impact of climate change on orchid pollination biology. This was not something Darwin had to worry about: orchid-mania reigned in the 19th century when collectors would cut down trees to access prized specimens or uproot whole colonies of a sought-after species, just to deny rivals.

"*Cryptostylis* orchids mimic female wasps, transferring pollen when males attempt to copulate with them"

Darwin's Orchids is full of surprises: plants of the wonderfully named *Dracula* genus (one is pictured above) are pollinated by fungus gnats, attracted by a blob of tissue that looks and smells like the fungus on which they normally lay eggs; *Orchis pauciflora* puffs out the pheromones that bumblebee queens use to mark males, while *Cryptostylis* orchids mimic female wasps, transferring pollen when male wasps attempt to copulate with them. Many orchids have no nectar, effectively being just bigger and brighter versions of flowers, like violets, that do.

There is also plenty about Darwin: the young explorer as well as the somewhat older man, fussing over specimens in his greenhouse. His orchid work and knowledge are given historical context, while those responsible, for our progress in understanding since then, like Swedish entomologist Bertil Kullenberg, also receive deserved attention.

This book will delight all those who have ever paused in a garden centre and, gazing at some extraordinary orchid, wondered, "Just what was evolution thinking?" Well, now, to some degree, we seem to know. Darwin would surely have been amazed by all the progress outlined here, and fascinated by such a wealth of new knowledge. ■

Adrian Barnett is a rainforest ecologist at Brazil's National Institute of Amazonian Research in Manaus

Taping over the red button

Ridding the world of WMDs is a paradoxical but deadly urgent business, finds **Rob Edwards**

Barriers to Bioweapons: The challenges of expertise and organization for weapons development by Sonia Ben Ouagrham-Gormley, Cornell University Press, $39.95

Unmaking the Bomb: A fissile material approach to nuclear disarmament and nonproliferation by Harold A. Feiveson, Alexander Glaser, Zia Mian and Frank N. von Hippel, MIT Press, $30/£20.95

IT is called Fogbank and it is a type of foam – toxic, explosive and highly flammable, and vital to the W76 nuclear warheads on Trident missiles. But the US government forgot how to make it. Over the nine years to 2009, the US National Nuclear Security Administration spent $69 million trying to remember how. A previous plant had been dismantled, few records had been kept and staff had left. The wheel simply had to be reinvented.

The story of Fogbank, first reported in *New Scientist* in 2008, is highlighted by Sonia Ben Ouagrham-Gormley as an example of how easy it is for organisations to forget things. When it comes to weapons of mass destruction, she suggests, this is an advantage, because it makes controlling their proliferation easier.

Her fascinating book, *Barriers to Bioweapons*, also shows that anyone wanting to develop biological weapons faces a raft of other difficulties. Of the five main bioweapons programmes to date, their key feature has been their failures, not their successes. In a forensic and compelling analysis, she describes how the Soviet Union, the US, South Africa and the Japanese terrorist group Aum Shinrikyo, all fell well short, despite spending billions of dollars over decades.

Then there's Iraq, where the government spent $80 million over 20 years on bombs that its scientists knew would not deliver most of the anthrax and other toxins they contained, but simply destroy them on impact.

The living microorganisms at the heart of these programmes are fragile and unpredictable, and the main barrier to producing bioweapons isn't access to materials and technologies, but the practical and organisational difficulties of actually getting devices to work. These weaknesses should be exploited to stem bioweapons development, she says. Present policy, stressing how easy it is to make bioweapons, only encourages terrorists.

"Present policy, stressing how easy it is to make bioweapons, only encourages terrorists"

The approach taken by the authors of *Unmaking the Bomb* is different, and for good reasons. They argue that the way to get rid of nuclear weapons is to control the fissile materials that cause the explosions.

Aftermath: in 1995, doomsday cult Aum Shinrikyo hit Tokyo's subway

THE ASAHI SHIMBUN VIA GETTY IMAGES

To back up their argument, they give a succinct, authoritative account of all the fissile material produced in military and civilian nuclear programmes since 1945. They conclude that, as at the end of 2013, there were about 1400 tonnes of highly enriched uranium and 500 tonnes of separated plutonium – together enough for more than 100,000 nuclear weapons.

Most of this material went into nuclear weapons programmes, mostly in Russia and the US. Some powered submarines, while plutonium separated from electricity-producing reactors was being stockpiled in Russia, the UK and France.

To ensure nuclear disarmament, the authors argue, all these materials have to be eliminated, using something like the Fissile Material Cut-off Treaty proposed by the UN in 1993. Since civil nuclear technology can be used to make bombs, they write, "it might be necessary for the world to do without nuclear power altogether".

Along with Ben Ouagrham-Gormley, they have another suggestion. International law should make working on nuclear or biological weapons a crime against humanity, thereby helping scientists and engineers exercise their consciences.

This is the kind of moral force that succeeded in ridding the world of slavery in previous centuries. These authors remind us, however, that the nuclear dangers we face are immediate, and that time is not on the side of humanity. ■

Rob Edwards is a consultant for *New Scientist*

Earth, wind and data

To understand our planet, data scientists must collect, store and make sense of vast amounts of information about it, finds **Laura Dattaro**

WHAT does a rocket launch from Vandenberg Air Force Base in California have to do with climate change? On the face of it, not much. But rockets armed with satellites designed to collect information on the planet's weather, atmosphere and ice cover can provide Earth scientists with terabytes of valuable data. With each terabyte the equivalent of 1,000 copies of the Encyclopaedia Britannica, making sense of it all is a huge task. Step forward data scientists, the people who hold the "sexiest job of the 21st century".

This year has proved NASA's busiest in over a decade. Since January, the organization has launched five space-based missions designed to study Earth. These include three satellites for studying rainfall, snowfall, carbon dioxide and soil moisture, and two International Space Station experiments collecting data on ocean winds and atmospheric aerosols.

Missions like these – along with global weather stations and high-tech ocean buoys – help Earth scientists and climatologists understand global weather patterns and warn of dangerous environmental shifts such as rising sea levels. But these important insights can only be made if someone can join the dots between the masses of data coming in from many sources.

Data scientists collect, catalog and analyze the resulting "big data" sets to spot trends. Data scientists have already proved their mettle in Silicon Valley, having played a vital role in assessing data collected from users of sites such as Facebook and Google to create bespoke advertising opportunities worth billions of dollars. The huge value of data scientists across a range of industries, and the high demand for them, has led some, including Steven Kempler, who manages one of NASA's Earth science data centers, to give the job its "sexy" moniker.

Within the field of Earth science, data scientists help to solve some of the planet's biggest problems, including climate change. When satellites first began collecting data on sea ice in the early 1970s, before climate change was widely recognized, only a small number of specialists were interested in studying it. That was until data scientists noticed that ice levels appeared to be declining over time. "After a few decades, it started to look like there might be a trend [toward a changing climate]," says Ruth Duerr, a data scientist at the National Snow and Ice Data Center in Boulder, Colorado.

A mixed-up medley

Duerr leads a team of researchers who develop new methods and products for storing and sharing vast amounts of Earth data. For example, she and her colleagues recently developed an archive for polar data – the Polar Information Commons – that aims to provide easy access to scientific data collected from the Arctic and Antarctic.

Often, data is collected in various formats by different researchers using different equipment, which can make them difficult to compare and study. The way data is formatted can also affect its suitability for specific software or algorithms. Kempler and his team work to standardize Earth data, ensuring that what is gathered from a variety of sources is stored in an accessible format for future researchers to use. As more sophisticated satellites and experiments on Earth collect ever more data, Kempler feels his task is growing.

At his data center alone, eight terabytes – nearly enough to hold the Library of Congress's entire printed collection – come in every day from satellite-based instruments studying Earth's precipitation, hydrology and atmospheric composition.

Once the information has been standardized, it has to be stored. To meet the need for cataloging Earth science's growing quantities of data, there is increasing demand for the expertise found in old-school library science. "When it comes to making information available and searchable, that's what libraries have been doing for centuries," says Nancy Ritchey, the archive branch chief for the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center.

Ritchey, who initially set out to be a weather forecaster, helps the federal center archive data from satellites, ocean buoys, and other sources. She researches different, complementary disciplines for better data management, such as using library scientists' ability to organize information accessibly alongside Earth scientists' expertise in specific research areas and statistical analysis. "You're there to ensure that the data remain accessible for the scientists today, and their grandchildren," she says.

"Having more data enables scientists to better understand our planet"

Crunch time

When it comes to crunching the data, students interested in Earth science should know their chosen field well, be it sea ice, atmospheric CO_2 or permafrost, Kempler says. But it is also worth choosing a program with a solid curriculum in data analytics to equip you with the skills to branch out. Two examples Kempler suggests fledgling Earth scientists could consider are those offered by the California Institute of Technology in Pasadena or the Rensselaer Polytechnic Institute in Troy, New York. Data analytics technologies like Hadoop and MapReduce, which help store files and process information, are also useful to know and can be learned from online courses or instruction books.

Ritchey's department at NOAA offers internships and scholarships to students in the environmental, computer, and library sciences, while Duerr says another good starting point for an Earth science career is in a government lab, with NASA, NOAA, or the US Geological Survey the three largest employers.

With a push from the White House and groups like the non-governmental organization the International Council for Science to make all data freely available to scientists and laypeople alike, the demand for data scientists is only going to increase. That's great news for those already in the field, says Ritchey. "Our ability to use multiple data sets has increased," she says. "Having more data, over longer periods of time, enables scientists today and in the future to better understand our planet." ■

Laura Dattaro is a writer based in New York City

CASE STUDY
OCEANS OF DATA

Ryan Abernathy isn't a computer scientist. But as an oceanographer at Columbia University's Lamont-Doherty Earth Observatory in Palisades, New York, he needs to manage terabytes of data about the ocean's salinity, temperature and current speeds, which often means writing code. Recognising how it would help his career, he largely taught himself through advice he found online. "The ability to work with data is something that people are expected to pick up along the way," Abernathy says. "But, culturally, we're recognizing more that data skills are critical for success in this field."

Abernathy studied physics as an undergraduate, but he wanted to move into a more interdisciplinary area of science, where he could apply his physics knowledge while studying the Earth's environment. Following a doctoral degree in climate physics and chemistry from the Massachusetts Institute of Technology in 2012, his research now focuses on what he calls "the weather of the ocean": how the density of water drives the currents, how the ocean stores heat and how salinity is related to the cycle of rainfall and evaporation. Much of his data comes from satellites and from ARGO, an array of thousands of floating ocean sensors, which together can help scientists such as Abernathy tease out the difference between natural ocean variation and the effects of human-driven climate change.

Increasing the amount of data is crucial to spotting potentially dangerous environmental shifts sooner rather than later, Abernathy says. "It's the only way we're going to be able to refine our understanding of these processes that are so important for our climate."

East Coast Office
225 Wyman Street
Waltham, MA 02451
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Research Scientist for Next-Generation Sequencing and Bioinformatics

The Wadsworth Center (Albany, NY) is seeking an outstanding scientist to join its Public Health Genomics Center. The successful applicant will be responsible for the development and implementation of next-generation sequencing and associated bioinformatics analyses in the research and public health programs of the Center. He or she will collaborate with research scientists to develop cutting-edge approaches for applications such as, pathogen identification, outbreak tracking, mapping drug-resistance determinants and novel genetic testing. In addition, there will be opportunities to participate in the various educational activities offered by the Wadsworth Center.

The Wadsworth Center (www.wadsworth.org) is the country's most comprehensive state public health laboratory with a staff of about 750. The Center provides a dynamic research environment focused on infectious, genetic and environmental diseases and their impact on human health. Through its initiative for Public Health Genomics, the Center will bring NGS and other advanced molecular technologies to public health testing, diagnosis, and research, further develop these technologies to address new and emerging challenges, and become a regional center of excellence for NGS in the area of public health genomics.

Ph.D. degree or equivalent and one to two years of relevant postdoctoral research preferred. Experience with various approaches for sample preparation for sequencing of microbial specimens and applications of different sequencing strategies is desired. Applicants should submit a cover letter, curriculum vitae, and contact information for at least three references by clicking Apply Now, referencing posting RS3/4/12137. Applications will be accepted until the position is filled and reviewed as they are received. AA/EOE.

Wadsworth Center
NEW YORK STATE DEPARTMENT OF HEALTH

University of Nebraska Lincoln

GROWING IANR

Faculty Positions
Institute of Agriculture and Natural Resources
The University of Nebraska-Lincoln

The Institute of Agriculture and Natural Resources (IANR) at the University of Nebraska-Lincoln (UNL) is committed to world-class excellence in applications of agricultural and life sciences towards a sustained high quality of life for the citizens of Nebraska, and for a quickly growing global population. Early in 2013, reflecting this commitment, IANR launched an initiative to hire new tenure-track faculty members in strategic impact areas of Science Literacy; Stress Biology of Plants, Animals, and Agroecosystems; Healthy Humans; Healthy Systems for Agricultural Production and Natural Resources; and Computational Sciences. This Phase 1 effort was very successful, resulting in the recruitment and hiring of 35 highly skilled tenure-line faculty members (with two searches still active).

We are pleased to announce Phase 2 of this effort with recruitment for an anticipated 30+ additional tenure-line faculty positions. The focus for Phase 2 will be to strengthen the six strategic impact areas in Phase 1, with an additional focus area – Drivers of Economic Vitality for Nebraska.

We invite you to view brief explanations of the positions currently being released and those to be released soon at http://ianr.unl.edu to explore whether your skills and experience make you a good fit for our team.

The positions will be advertised and posted beginning December 1, 2014. We invite you to visit the UNL employment web site at http://employment.unl.edu to learn which positions are posted.

The University of Nebraska is committed to a pluralistic campus community through affirmative action, equal opportunity, work-life balance, and dual careers.

IANR

Opportunities for Informatics Research at HARVARD MEDICAL SCHOOL

The Biomedical Informatics Research Training (BIRT) Program is a consortium of leading informatics laboratories at Harvard. It is supported by a grant from the National Library of Medicine, National Institutes of Health. For United States citizens and permanent residents, this post-doctoral fellowship provides stipend, tuition, and travel funds. Selected fellows are provided with many opportunities for training, research, interaction, and collaboration. All fellows also pursue the two-year Harvard Medical School Biomedical Informatics MMSc.

The MMSc is a post-doctoral degree program that consists of course work and mentored research. Fellows in our program choose from one of four possible tracks: Bioinformatics; Clinical Informatics; Imaging Informatics; and Population Health Informatics.

To learn more, visit: **informaticstraining.hms.harvard.edu/**

In addition to the BIRT program, the Center for Biomedical Informatics (CBMI) offers a number of other training and research opportunities.

For more information about our programs, contact
Aimee Doe, Program Coordinator, at **Aimee_Doe@hms.harvard.edu**

Harvard University
Cambridge, Massachusetts

Tenure-Track Assistant Professorship in Chemistry and Chemical Biology

Candidates are invited to apply for an open-field tenure-track assistant professorship in the Department of Chemistry and Chemical Biology at Harvard University. The appointment is expected to begin on July 1, 2015. The tenure-track professor will be responsible for teaching at the undergraduate and graduate levels. We are seeking candidates who have an outstanding research record and a strong commitment to undergraduate and graduate teaching. Doctorate required by expected start date. Candidates should arrange to have three letters of recommendation sent independently and provide a curriculum vitae, statement of teaching philosophy, list of publications, and outline of their future research plans.

All applications and supporting materials must be submitted via the ARIeS portal (http://academicpositions.harvard.edu/postings/5829) **no later than December 15, 2014.**

Harvard is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability status, protected veteran status, or any other characteristic protected by law.

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

2015 The Louisa Gross Horwitz Prize for Biology or Biochemistry

The Louisa Gross Horwitz Prize was established under the will of the late S. Gross Horwitz through a bequest to Columbia University and is named to honor the donor's mother. Louisa Gross Horwitz was the daughter of Dr. Samuel David Gross (1805-1889), a prominent surgeon of Philadelphia and author of the outstanding *Systems of Surgery* who served as President of the American Medical Association.

Each year since its inception in 1967, the Louisa Gross Horwitz Prize has been awarded by Columbia University for outstanding basic research in the fields of biology or biochemistry. The purpose of this award is to honor a scientific investigator or group of investigators whose contributions to knowledge in either of these fields are deemed worthy of special recognition.

The Prize consists of an honorarium and a citation which are awarded at a special presentation event. Unless otherwise recommended by the Prize Committee, the Prize is awarded annually. Dr. James P. Allison, University of Texas MD Anderson Cancer Center was the 2014 awardee.

Qualifications for the award

The Prize Committee recognizes no geographical limitations. The Prize may be awarded to an individual or a group. When the Prize is awarded to a group, the honorarium will be divided among the recipients, but each member will receive a citation. Preference will be given to work done in the recent past.

Nominations must be submitted electronically at: http://www.cumc.columbia.edu/research/horwitz-prize
All communications and materials must be written in the English language.
Deadline date: January 30, 2015
Re-nomination(s) are by invitation only. Self-nominations are not permitted.

Nominations should include:

1) A summary, no more than 500 words long, of the research on which this nomination is based.
2) A summary, no more than 500 words long, of the significance of this research in the fields of biology or biochemistry.
3) A brief biographical sketch of the nominee, including positions held and awards received by the nominee.
4) A listing of up to ten of the nominee's most significant publications relating to the research noted under item 1.
5) A copy of the nominee's curriculum vitae.

Fellowships for Postdoctoral Scholars

Woods Hole Oceanographic Institution

New or recent doctoral recipients with research interests associated with the following are encouraged to submit scholarship applications prior to January 5, 2015.

Departments - Awards related to the following areas are anticipated: Applied Ocean Physics & Engineering; Biology; Geology & Geophysics; Marine Chemistry & Geochemistry; Physical Oceanography; and in cooperation with the USGS laboratory located on the WHOI campus.

Institutes – Each Institute fosters interdisciplinary research addressing critical issues, and we will award a scholarship to support related research: Ocean and Climate Change Institute; Coastal Ocean Institute; Ocean Exploration Institute; Ocean Life Institute.

The Center for Marine and Environmental Radioactivity (CMER) will award a fellowship for research on natural and human-made radioactive substances in the environment including the study of their sources and fate or use as tracers of ocean processes.

Awards are competitive, with primary emphasis placed on research promise. Scholarships are 18-months with an annual stipend of $58,000, a research budget and eligibility for health and dental insurance. Recipients are encouraged to pursue their own research interest in association with resident staff. Communication with potential WHOI advisors prior to submitting an application is encouraged.

Further information may be obtained at:
www.whoi.edu/postdoctoral

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University of Utah
Huntsman Cancer Institute
Department of Oncological Sciences

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Review of applications will continue until the position is filled or the search is closed.

For full consideration please apply at the following link:
http://utah.peopleadmin.com/postings/36883

Inquiries may be submitted to Recruitment Director at
hci.recruitment@hci.utah.edu

The University of Utah Health Sciences Center is a patient focused center distinguished by collaboration, excellence, leadership, and Respect. The University of Utah HSC values candidates who are committed to fostering and furthering the culture of compassion, collaboration, innovation, accountability, diversity, integrity, quality, and trust that is integral to the mission of the University of Utah Health Sciences Center.

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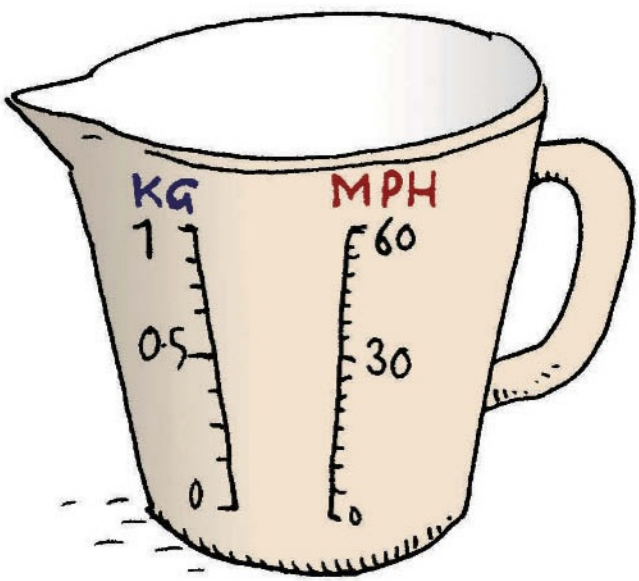
The University of Utah values candidates who have experience working in settings with students from diverse backgrounds, and possess a demonstrated commitment to improving access to higher education for historically underrepresented students.



PAUL MCDEVITT

MUPHRY'S Law holds, as regular readers may recall, that whenever one criticises editing or proofreading, there will be a fault in what you have written. It appears to have the power to propagate errors to texts adjacent in space and time (29 March). So it is with some trepidation that we turn to Peter Henderson's report of an item in *The Independent*, a newspaper, on 22 October, discussing overfishing.

Unsurprisingly to readers of this column, taking larger fish, including predators, allows small fry to thrive. The piece says of the big fish that "Their volume – by weight – has fallen by 67 per cent in the past century".

Peter supposes that "it makes a change from the oft-heard 'volume of calls' and 'amount of people'".

THE Independent newspaper is not the only organisation to have got rid of many of its subeditors or copy-editors – the people whose job includes, or included, ensuring that writers' work is original, but not more original than reality. A subeditor colleague forwards a blog entry on iflscience.com about a paper in the journal *Ethology* discussing the sociability of fish.

It includes this: "Although association preferences documented in our study theoretically could be a consequence of either mating or shoaling preferences in the different female groups investigated (should we cite the crappy X paper here?), shoaling preferences are unlikely drivers…"

Feedback has redacted the name of the author of the paper that went uncited, until such time as we can retro-review it.

INEXORABLY, *The Independent* raises its head again. Craig Borland mentions a story that, if true, would suggest that the difficulty of putting the Philae lander onto a comet was overstated. On 15 November, the paper reported that "scientists were quick to expound the overall success of the mission lander… on Comet 67P/Churyumov-Gerasimenko, 311 miles away from Earth." Surely 311 miles (by coincidence, almost exactly 500 kilometres) is within the writer's experience? It's about twice the length of Wales. Or do horizontal distances not mentally convert to the vertical without training? Feedback has forgotten what it was like not to know.

PHILAE generated a gratifying amount of interest and publicity for solar system exploration. The plot of the plucky little lander's lone battle with the lack of gravity obviously helped.

Newspapers gave constant updates. A truncated example of one Tweet™ turned out slightly prophetic (this is an allowed use of the trademark, as discussed on 22 November). Andy Coleman sends a snapshot of the European Space Agency Twitter feed on 12 November, relaying a message from the *Daily Mirror* newspaper: "Watch the Rosetta probe landing LIVE with our coverage of its historic miss." The Agency replied, very officially: "@Philae2014 right a bit ;)" If only…

SIMILAR thoughts inspired Malcolm Muckle to send an image from a famous Street View service of the UK's M1 motorway near Leicester. It shows a sign indicating that tourists should take the next exit for the National Space Centre. Above this is another sign, reading "Park and Ride".

Interestingly (at least to anyone who shares Feedback's fascination with the iconography of road signs) the attractions of the National Space Centre are illustrated by the outline of a V-2 rocket (6 September, p 48).

THAT image of a V-2 reminds Feedback of the less-savoury side of space research. Feedback has previously noted the odd connection between Thomas Pynchon's mammoth 1973 novel *Gravity's Rainbow* and the history of rocketry (1 March). One of the thousands of plot strands is the suggestion that the British authorities deliberately "walked" the *Vergeltungswaffen* – "revenge weapons" – away from their west London homes and toward those of our ancestors in the east.

Surely this was an example of those universal Pynchon themes, paranoia and conspiratorial thinking? No. We find in Christy Campbell's 2013 book *Target London* references to documents in the UK Public Record Office detailing the plan. It included placing fake obituaries into newspapers in north-west London, just in case the Nazis monitored these to find out where the rockets fell, concluded that they had overshot and shortened their missiles' range. It worked.

FINALLY, plucky little lander Philae got a cuddly metaphor to help the story along. Lawrence Moulin reports *The Guardian* newspaper on 6 August describing it as "having the same weight as 'a newborn elephant'". The vagaries of retroactive subediting online seem to have removed this from the website: but it is preserved in a reader's letter welcoming "a new addition to the Guardian weights and measures lexicon".

Lawrence notes Feedback's observation that the elephant is already a universal unit (2 June 2012). He envisages a standard elephant kept carefully in Paris. The practice of keeping standard masses in a vacuum may, though, have to be rethought.

"Private company launches Antares Rocket to ISS," Fox News announced on 27 October. A while later, as problems emerged: "Unmanned NASA cargo rocket explodes on launchpad." They clearly know who to praise and who to blame

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Internal reservoirs

We can't live for long without water. But our food is turned into water inside us – carbohydrates are metabolised to carbon dioxide and water. So could we live on dry biscuits alone?

No, you can't survive on the water produced during the breakdown of the carbohydrates in dry biscuits alone – a process termed catabolism. Theoretically, you could eat enough biscuits to provide the recommended 2 litres of water you need daily. But if we assume biscuits to be pure glucose – the end breakdown product of the starch found in flour – you would need to eat 2.4 kilograms of biscuit to get the required water.

However, carbohydrates can only be broken down when they are in an aqueous solution. So to make a thick biscuit porridge that the body could deal with (say 30 per cent solids by weight), the necessary 5.5 litres of water would need to come from you. In other words, you would need to put twice as much water in as you would recover from catabolism.

Generally, food is pretty wet – about 50 to 70 per cent water – which means you don't need to supply much water from your body. But biscuits are dry, which is why people dip them in their tea before eating.

We need a lot of other things besides water and carbohydrates to live healthily, of course: vitamins and minerals as well as salts, proteins and fats. So don't try this experiment at home.

Simon Goodman
Griesheim, Germany

Bowled over

Water moves about in my toilet bowl when it's windy outside. Why?

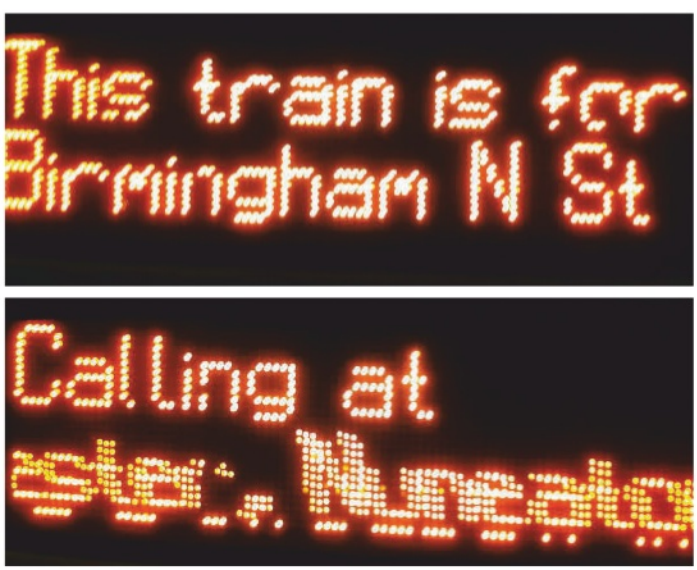
The plumbing of domestic drains is behind this phenomenon. Your toilet bowl has a continuous connection to the sewer underground, but it also contains a connection to the open air. The purpose of this vent pipe is to ventilate the soil pipe, which carries water from the toilet to the sewer.

Your toilet has a U-bend which holds water to form a seal and prevent noxious fumes drifting from the sewer into the bathroom. When the toilet is flushed, water rushing down the pipe creates negative pressure behind it, which would drag this water seal out of the U-bend. The vent pipe prevents this by allowing some outside air to be pulled into the pipe instead.

The vent pipe needs to be installed with its outlet away from windows because its direct connection to the sewer will allow gases to escape. This is why most are at roof level.

When the wind blows over the end of the vent pipe the Bernoulli effect comes into play, creating suction in the pipe which draws water out of the U-bend. If the wind is gusting, water in the toilet bowl can move up and down.

Malcolm Nickolls
Aylesbury, Buckinghamshire, UK



This week's questions

FILTERED WATER

As a photographer, I have always wondered why the light reflecting off water, foliage and glass is affected by polarising filters, but the light reflecting off metal surfaces is not.

Joe Martinez
By email, no address supplied

TRAIL OF MYSTERY

In my grandmother's house a snail-trail-like substance is visible on the mat in the conservatory each morning. There are no apparent signs of a snail living in the room and the door is locked at night. Is there another insect or animal that causes this effect?

Shane Duffy (age 12)
Dublin, Ireland

SLOPING OFF

On my train to work there is a dot-matrix sign which has the words "Calling at" in a Roman font, but the station names below it in italic font. However, if you take a photo of the sign all the words appear Roman (see photo, top).

If the photograph catches the sign at the correct moment, you can see that the italic font is created by the dots on the sign lighting up with some clever on-off timing that fools the eye (see photo, bottom). All the dots are in vertical and horizontal rows. How is this italic effect created and, more intriguingly, why bother?

Craig Mackie
Easton on the Hill, Northamptonshire, UK

The writers of answers that are published in the magazine will receive a cheque for £25 (or US$ equivalent). Answers should be concise. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and an email address if you have one. New Scientist retains total editorial control over the published content.

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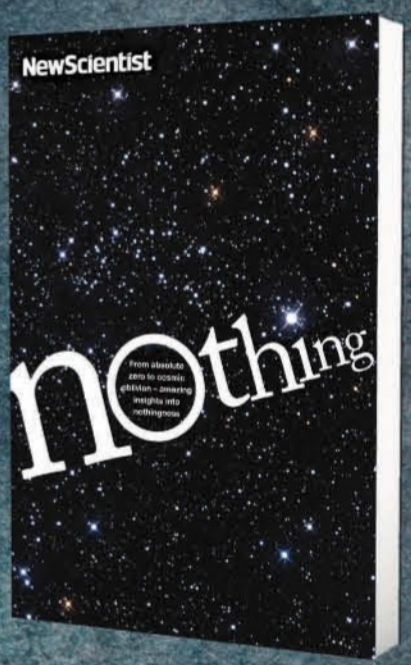
Everything you always wanted to know about nothing



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